Dr Stamps G.T.W.

REPORT ON THE FOURTH COMMONWEALTH MYCOLOGICAL CONFERENCE 1948

THE COMMONWEALTH MYCOLOGICAL INSTITUTE
KEW, SURREY
1948

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1. Calling of the Conference

A RESOLUTION was passed at the first Imperial Mycological Conference in 1924 to the effect that, in view of the value to overseas mycologists of such meetings, further conferences should be arranged every five years. Owing to the outbreak of war in September, 1939, the fourth meeting which was arranged for that year had to be postponed; the Director's report on the work of the Imperial Mycological Institute was, however, circulated to the Governments concerned and is reprinted as Appendix III to this report. At the Imperial Agricultural Bureaux Review Conference in 1946 the importance of an early resumption of Specialist Conferences was stressed and in April, 1947, the Executive Council decided to invite Governments to hold a Commonwealth Mycological Conference in London in June, 1948. The month was later changed to July and invitations were accordingly conveyed to overseas Governments of the British Commonwealth and to certain Government Departments of the United Kingdom for a conference to be held in London in July, 1948.

2. Delegates

The following delegates attended the Conference:—

A—Home and Dominion Governments, &c.

UNITED KINGDOM	MR. G. SAMUEL MR. F. C. BAWDEN MR. W. C. MOORE DR. C. E. FOISTER PROFESSOR A. E. MUSKETT DR. R. A. E. GALLEY
CANADA	DR. G. H. BERKELEY MR. I. L. CONNERS DR. W. L. GORDON
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EIRE	DR. R. MCKAY
INDIA	DR. B. B. MUNDKUR DR. K. D. BAGCHEE

SOUTHERN RHODESIA	DR. J. C. F. HOPKINS
CEYLON	MR. W. V. D. PIERIS

B—Colonial Governments, &c.

COLONIAL EMPIRE	MR. G. F. CLAY DR. H. H. STOREY
CYPRUS	DR. P. LOIZIDES
GOLD COAST	MR. C. A. LISTER
KENYA	DR. LE PELLEY
MAURITIUS	MR. P. O. WIEHE
NIGERIA	MR. A. C. TRUEBLOOD
TRINIDAD	PROFESSOR R. E. D. BAKER

C—PROFESSOR R. E. D. BAKER and MR. DALE represented the Imperial College of Tropical Agriculture, Trinidad; MR. H. OWEN and MR. N. F. ROBERTSON, the West African Cacao Research Institute, Gold Coast; MR. C. E. T. MANN, the Rubber Research Institute of Malaya; MR. A. T. PUGSLEY and MISS C. M. EARDLEY, the Waite Agricultural Institute, South Australia.

VISITORS

Invitations to attend the Conference and take part in the discussions were issued to the staffs of Agricultural and Horticultural Research Stations, University Departments, and individual mycologists in the United Kingdom and to the representatives of various firms interested in the manufacture of fungicides. Many visitors were able to attend and they made valuable contributions to the discussions.

3. Place of Meetings

By courtesy of the Governing Body of the Imperial College of Science and Technology, meetings of the Conference were held in the Metallurgical Lecture Theatre of the College, Prince Consort Road, South Kensington. In addition the Governing Body arranged for delegates and visitors attending the Conference to have meals at the College Union.

The Director of the Imperial Institute very kindly granted the use of the Institute's cinema for the showing of a film at the joint meeting with the Commonwealth Entomological Conference.

4. Programme

The following programme was arranged for the Conference:

Monday, 19th July

10 *a.m.* Opening of the Conference by LT.-COL. J. G. ROBERTSON, Chairman of the Executive Council of the Commonwealth Agricultural Bureaux.

10.30 *a.m.* THE WORK AND ORGANIZATION OF THE COMMONWEALTH MYCOLOGICAL INSTITUTE.

11 *a.m.* to 1 *p.m.* ADMINISTRATIVE MEASURES AGAINST PLANT DISEASES. (*a*) LEGISLATION.

2.30 to 4.30 *p.m.* ADMINISTRATIVE MEASURES AGAINST PLANT DISEASES. (*b*) SEED CERTIFICATION AGAINST SEED-BORNE DISEASES.

Tuesday, 20th July

10 *a.m.* to 1 *p.m.* THE CONTROL OF VIRUS DISEASES (WITH SPECIAL REFERENCE TO CACAO VIRUSES, VIRUS DISEASES OF STONE FRUITS, PHLOEM NECROSIS OF TEA, TOMATO SPOTTED WILT).

2.30 to 4.30 *p.m.* THE CONTROL OF VIRUS DISEASES (CERTIFICATION OF VEGETATIVELY REPRODUCED CROPS).

Wednesday, 21st July

Visit to Rothamsted Experimental Station.

Thursday, 22nd July

10 to 11.30 *a.m.* THE DIAGNOSIS OF NUTRITIONAL DISORDERS.

11.30 to 1 *p.m.* LOSSES DUE TO FUNGI IN STORED PRODUCTS.

2.30 to 4.30 *p.m.* TAXONOMIC MATTERS, INCLUDING:

(*a*) THE ORGANIZATION OF HERB. I.M.I.

(*b*) THE CULTURE COLLECTION OF HERB. I.M.I.

(*c*) THE USE OF MICROFILM IN THE DOCUMENTATION OF SYSTEMATIC MYCOLOGY.

(*d*) A COMMONWEALTH LIST OF COMMON TROPICAL PLANT DISEASES.

Friday, 23rd July

10 *a.m.* to 1 *p.m.* FUNGICIDES, INCLUDING:

(*a*) THE CERTIFICATION OF FUNGICIDES.

(*b*) THE USE OF FUNGICIDES IN THE CONTROL OF TROPICAL DISEASES.

(*c*) THE DEVELOPMENT OF NEW FUNGICIDES.

2.30 to 4.30 *p.m.* JOINT MEETING WITH THE COMMONWEALTH ENTOMOLOGICAL CONFERENCE.

(*a*) THE APPLICATION OF INSECTICIDES AND FUNGICIDES FROM THE AIR.

(*b*) RECENT DEVELOPMENTS IN PEST AND DISEASE CONTROL MACHINERY.

Saturday, 24th July

10 to 11 *a.m.* BIOLOGICAL CONTROL OF INSECTS AND WEEDS.

11 *a.m.* to 12 *noon.* FOREST PATHOLOGY.

12 *noon* to 1 *p.m.* CLOSING SESSION.

3 to 5 *p.m.* VISIT BY CONFERENCE DELEGATES TO THE COMMONWEALTH MYCOLOGICAL INSTITUTE.

5. Government Dinner to Delegates of the Commonwealth Entomological and Mycological Conferences and to Members of the Executive Council of the Commonwealth Agricultural Bureaux

His Majesty's Government in the United Kingdom gave a dinner at Claridge's Hotel on the evening of Thursday, 22nd July, to delegates of both Conferences and to members of the Executive Council of the Commonwealth Agricultural Bureaux. The Right Honourable Tom Williams, M.P. (Minister of Agriculture and Fisheries) presided, and proposed the toast of 'The Entomological and Mycological Conferences', to which Lt.-Col. J. G. Robertson responded. Mr. Gordon Walker, M.P. (Commonwealth Relations Office) proposed the toast of 'The Delegates from Overseas', to which Mr. H. G. Crawford (Canada) and Dr. J. C. F. Hopkins (Southern Rhodesia) responded.

6. Opening of the Conference

The Conference was opened by Lt.-Col. J. G. Robertson, B.S.A., F.R.S.A., Chairman of the Executive Council of the Commonwealth Agricultural Bureaux, at 10 a.m. on the 19th July. Colonel Robertson welcomed the delegates and visitors to the Conference; he expressed the opinion that the Conference gave them a fine opportunity to get together to discuss matters of mutual concern and to plan for the future, and he stressed the importance of their being able to make personal contacts for the exchange of ideas outside the Conference proper.

Colonel Robertson defined the Commonwealth Agricultural Bureaux and outlined the constitution and work of the Executive Council and said that the Conference was pleased to have the recently appointed representative from Ceylon. He paid tribute to the work of Sir David Chadwick, Secretary of the Executive Council up to 1946, and to that of the present Secretary, Sir Herbert Howard. The Council directs two Institutes and ten Bureaux as well as a Bureau of Biological Control in Canada and the Commonwealth Potato Collection. In response to a desire expressed by certain of the Dominions the names of the institutes and bureaux had been changed, the word Commonwealth being substituted for Imperial, but the work done by them was the same as before. The present Conference was mainly concerned with the Commonwealth Mycological Institute. The chairman said that they had been fortunate in having three very efficient directors: Sir Edwin Butler, Mr. S. F. Ashby, and the present one Dr. S. P. Wiltshire.

At the third Conference in 1934 it was proposed that the next meeting should be held in 1939; owing to the outbreak of war in that year no Conference was held, although a certain number of overseas

delegates did arrive, and Mr. Ashby's report was circulated to the Governments concerned. At the Imperial Agricultural Bureaux Review Conference held in 1946 the importance of the early resumption of Specialist Conferences was stressed, and in April, 1947, the Executive Council decided to invite Governments to hold a Mycological Conference in London in 1948; this was subsequently arranged to take place in July.

Colonel Robertson pointed out that during the fourteen years that had elapsed since the last Conference a great deal of work has been done by mycologists in fighting disease and hunger. The importance of plant disease legislation in preventing the introduction of disease into new territories had been brought out forcibly during the war and he considered it a first line of defence; legislative proposals of a far-reaching nature were to be put before the present Conference, and a Pan-African Phytosanitary Conference was expected to meet in August to consider further proposals for plant quarantine organization for the whole of Africa. There had been rapid developments in the production of fungicides. To-day, more than ever before, the vital importance of mycological work in connexion with food production was recognized.

The chairman said that the staff of the Commonwealth Mycological Institute were fully occupied and somewhat cramped for space, and that money was none too plentiful. The Institute was financed by Governments through the Executive Council, who were aware that quarters were inadequate and larger buildings most desirable; this was receiving the attention of the Council at the present time and he hoped that more room would be provided as soon as land and money were made available. After repeating his cordial welcome to the delegates he declared the Conference open.

7. The Work and Organization of the Commonwealth Mycological Institute

Following the opening address by Lt.-Col. Robertson, the Director reviewed the work of the Commonwealth Mycological Institute since the last Conference; his review is published as Appendix I to this report.

Two sub-committees were then appointed:

(*a*) to consider the work and needs of the Institute, composed as follows:

Mr. G. Samuel
Dr. G. H. Berkeley
Dr. G. H. Cunningham
Dr. J. G. Davies

Dr. Van der Plank
Dr. R. McKay
Dr. B. B. Mundkur
Dr. J. C. F. Hopkins
Professor R. E. D. Baker
Mr. P. O. Wiehe
Mr. W. V. D. Pieris
Dr. P. Loizides.

(The report of this sub-committee is included in Resolution 7.)

(*b*) to draft resolutions, composed as follows:

Mr. W. C. Moore
Dr. H. H. Storey
Mr. I. L. Conners
Mr. N. F. Robertson.

8. General Discussions of the Conference

A summary of the papers and discussions of the Conference is given as Appendix II to this Report.

9. Visits to Research Stations

On 21st July many of the delegates visited Rothamsted by kind permission of the Director, Dr. Ogg, and were shown the work in progress in the Plant Pathology Department. In the absence of the Director, Mr. F. C. Bawden welcomed the delegates and directed the itinerary. In the morning the visitors toured the laboratories where the members of the Department demonstrated the research work. In the afternoon the field experiments were viewed. The party was entertained to lunch and tea.

Delegates were also able to join the meetings of the British Mycological Society on 16th and 17th July at Cambridge. The plant pathology field meeting included visits to the Botany School Field Station, the Plant Virus Research Station, the Commonwealth Potato Collection, and the Plant Breeding Institute.

10. Demonstrations

An exhibit arranged by the Commonwealth Mycological Institute was on show throughout the Conference. It included three types of microfilm reader, one by Messrs. W. Watson & Sons, Ltd., a second by Messrs. Edison Swan, Ltd., and a third by Messrs. Cook & Perkins, a display of microscopes by Messrs. W. Watson & Sons, Ltd., C.M.I. publications, and a demonstration of the C.M.I. culture collection.

The Association of Applied Biologists arranged a Conversazione on Friday, 23rd July, from 5 to 10 p.m. in the Botany Department of the Imperial College. The comprehensive series of exhibits, staged by the Research Stations, University Departments, Agricultural Departments, N.A.A.S., Agricultural Research Council, and others, afforded Conference delegates and visitors an excellent opportunity of acquainting themselves with research work in progress and of meeting the various workers.

11. Resolutions

The following resolutions were adopted by the Conference:

1. That the following recommendations of this Conference be transmitted to the Conference on Continental Quarantine for Africa to be held in London on August 2nd, 1948.

   (*a*) This Conference supports the proposal for an African Phytosanitary Convention. It is suggested that:

   (i) Such a Convention should embrace all the territories south of the Sahara, including the Anglo-Egyptian Sudan, Abyssinia, and Eritrea, and that these territories should be regarded as one area for administrative purposes in connexion with the introduction and quarantine of plants; but the pests and disease position in the part of Africa north of the Sahara should be kept under constant review in order that, if considered necessary, steps could be taken later to secure the co-operation of countries concerned, so as to extend the area covered by the Convention to embrace the whole of the Continent.[1]

   (ii) Notwithstanding the previous suggestion, it might be necessary for ease of administration to organize regions within the area covered by the Convention. In this connexion the Conference draws attention to the satisfactory arrangements now in operation in the southern African region, comprising the Belgian Congo, the Union of South Africa, Southern Rhodesia, Northern Rhodesia, and Nyasaland, and in East Africa comprising Kenya, Uganda, Tanganyika, and Zanzibar, with the suggestion that a similar regional arrangement might be organized for other parts of the area.

   (iii) While there should be common minimum legislation throughout the area, any territory should be free to make more stringent regulations if it is thought desirable to do so. In order to stimulate mutual confidence consulta-

[1] Some delegates abstained from voting on this item.

tion with other member states should be established as a principle.

(iv) A permanent commission, comprising representatives of the powers subscribing to the Convention, should be set up, charged with examining the existing arrangements in all territories for the control of importation of plants, with a view to instituting and co-ordinating common measures of protection against the importation of diseases and pests, as well as common action inside Africa against diseases and pests occurring in the several territories.

(v) The establishment of quarantine measures is important and the commission should examine existing conditions and where necessary set up or make recommendations for the setting up of further quarantine stations.

(*b*) Subject to the provision of adequate funds and staff, the Conference supports the recommendations of the Brussels Conference that the Commonwealth Mycological Institute should be recognized as the centre of information on the distribution of plant diseases.

2. In view particularly of the danger of introducing South American leaf disease of *Hevea* (*Dothidella ulei*) into south-east Asia. the Conference recommends that Governments of rubber-producing countries in that region should consider the advisability of agreeing to a Phytosanitary Convention similar to that already proposed for Africa.

3. The Conference is of the opinion that the continued need for an increased production of agricultural and horticultural crops calls for an adequate supply of the highest quality seed for all crops propagated by seed. To this end the Conference recommends that at least one mycologist or plant pathologist should be attached to official Seed Testing Stations within the Commonwealth.

4. The Conference is of the opinion that there is urgent need for expansion of research on problems of wastage caused by fungi in foodstuffs and other stored products.

5. The Conference would welcome the issue, by the Commonwealth Mycological Institute, of a broadsheet of items of mycological and phytopathological interest contributed by Commonwealth workers.

6. This Conference recommends that the agenda of future Conferences should permit some days or half days entirely free from official business to enable delegates to have informal meetings and discussions.

7. The Conference unanimously adopted the following report of the Technical Committee set up to examine the work and organization of the Commonwealth Mycological Institute:

'We were appointed at the opening session of the Conference on the 19th July and met on Monday, 19th, Tuesday, 20th, and Friday, 23rd July.

'We discussed the work and organization of the Institute with Dr. Wiltshire and Sir Herbert Howard, who explained fully the projects in hand, those contemplated in the near future, accommodation, and the financial provision made by the Review Conference of 1946.

'We wholeheartedly approved of the programme as set forth and are of the opinion that, at the earliest opportunity, additional funds should be provided for the expansion of the work, the continuance of certain projects under way, and the initiation of a limited number of new projects.

'These may be referred to in greater detail as follows:

'1. We note with some disappointment that no more than six of the eleven handbooks on the diseases of tropical and subtropical plants, recommended by the Imperial Mycological Conference of 1929, have so far been published. We strongly urge that efforts will be made by the Institute to obtain authors for the remaining volumes projected and that such assistance as is feasible will be given by the Institute in the preparation of these volumes. We note with satisfaction that preparations for a handbook on the Diseases of Rice are already far advanced.

'2. We welcome the proposal of the Institute to publish a series of monographs on groups of fungi and particular diseases, written by specialists, and are pleased to note that the manuscript of one, on British Smuts, is already near completion and that a start has been made on one on Coffee Rust.

'3. We welcome, also, the recent initiation of microfilm reproduction of rare systematic works and volumes of the *Review of Applied Mycology* out of print, and feel confident that this new service will be of increasing value in meeting the needs of mycologists for literature otherwise inaccessible.

'4. We note that the Commonwealth Conference on Culture Collections recommended that the Institute should maintain the central collection of cultures of fungi for distribution throughout the Commonwealth and we consider the Institute to be the most appropriate centre for this purpose. The efficient maintenance of the Collection, for which additional staff and apparatus are required, is essential, and we would urge that adequate financial provision be made as soon as possible.

'5. We welcome the proposal for a series of loose-leaf sheets describing plant pathogenic fungi, which we consider will be

an invaluable addition to the library of every laboratory of plant pathology, besides being of great assistance in the training of students and extension staffs. We recommend also that a limited number of carefully checked exsiccata be distributed with these sheets to approved institutions, at the discretion of the Director.

'6. We suggest that an additional entry be inserted in the index of the *Review of Applied Mycology* to cover new records of diseases.

'7. *Buildings*: We view with much concern the inadequate accommodation provided by the present Institute building, which has been occupied without extension for the past eighteen years of continuous development. We point out that the normal expansion of the activities of the Institute which now cover all aspects of plant pathology is entirely dependent on the provision of greatly increased accommodation, and of more staff. We therefore recommend that the Executive Council should further examine the possibility of acquiring at an early date a site suitable for a new building, which will allow of normal expansion for several decades to come. We further recommend that the urgent need for financial provision to meet these requirements of buildings and staff be brought to the notice of the Review Conference of 1950.

'We desire to express our appreciation of the outstanding work at present being performed by the Institute and note with great satisfaction that this is recognized beyond the borders of the Commonwealth. This was recently exemplified by the resolution passed at the Conference of Colonial Experts held in Brussels in 1947, which recommended that the Institute should be asked to act as a clearing house of information for the proposed International African Phytosanitary Convention.'

12. Votes of Thanks

A vote of thanks to the authorities of the Imperial College of Science and Technology and to the Imperial College Union for the use of their rooms for the meetings and for the facility granted to delegates and visitors of taking meals in the College refectory was passed. Votes of thanks were also passed to the Director of the Imperial Institute for the use of the Cinema of the Institute, to the Director and staff of the Commonwealth Mycological Institute for their work in connexion with the conference, to the Resolutions Committee, to the Chairman, Lt.-Col. Robertson, and to Rothamsted Experimental Station and the Association of Applied Biologists for the excellent displays they had arranged for the benefit of the delegates.

APPENDIX I

The Director's Review of the work of the Institute 1934–48

FOURTEEN years have passed away since the last Imperial Mycological Conference was held. As the Chairman has remarked, a conference was arranged for 1939, but had to be cancelled because of the outbreak of war, though about half a dozen delegates actually arrived and met formally at the Institute, when the Director, Mr. S. F. Ashby, read to them his Review of the preceding five years. This Review was subsequently circulated to the governments of the Empire and it is unnecessary for me to go over the ground again. Mr. Ashby retired at the end of 1939 and the period with which I am concerned is from the beginning of 1940 onwards.

The main activity of the Institute information service, the *Review of Applied Mycology*, has been maintained throughout the war. For some time it has appeared late owing to printing difficulties, but it is a tribute to our printers that the delay has never exceeded a month and often has been much less. The disruption of communications made it impossible to obtain all published work during the war, but we managed to get a good proportion of enemy literature and since the capitulation it has been our aim to abstract all papers that contain useful information whenever they were published in order to present a complete record of the literature of our subject. The *Review* remains the constant preoccupation of the information service and every effort is made to maintain and improve the standard of our work. Our chief abstractor, Miss Secker, has been with us from the start and it is a pleasure to me to acknowledge the very notable service she has consistently rendered for so many years.

The reduction of incoming literature consequent upon the outbreak of war afforded us for the first time an opportunity to overhaul thoroughly our organization and technique. It had been our practice for eighteen years to record all abstracts as they were made on 6 in. by 4 in. cards, each card being filled before starting another. It was always regarded as a temporary index to enable the abstractors to avoid duplicating abstracts, the cards being filed under the host plants concerned. By adopting 5 in. by 3 in. cards and single entries on a card, it was possible to file each card under the disease of the crop and automatically to start building up a bibliography of phytopathological literature which should become increasingly valuable as the years go by. The incorporation of subject indexes of separates into that bibliography constituted a major task which was successfully accomplished with the help of the abstractors.

After the 1914–18 War very great difficulty was encountered in tracing the original descriptions of new species of fungi published during the war years. Many hours of labour were entailed in irritating and frequently unsuccessful search of the literature for these species. At the beginning of 1940 we immediately started listing all new genera and species of fungi, new combinations, and new names published, and these were subsequently printed as supplements to the *Review of Applied Mycology*. The issue of the supplements has continued at six-monthly intervals and the name has recently been changed to the more appropriate one of *Index of Fungi*. The lists of new species of fungi published by Petrak in *Just's Botanischer Jahresbericht* were always late in appearing but were continued during the war, the last appearing in 1943, and including all species down to the end of 1935. Professor Petrak continued his

compilation till 1945 when he had indexed literature up to the end of 1938, and then gave up. He has now undertaken to complete his list to the end of 1939 and this Institute hopes to publish it. I understand that all stocks of Petrak's earlier lists have been destroyed and I trust that it may prove possible for the Institute to arrange for the reprinting of these also.

Another project that we launched during the war years was the publication of distribution maps of plant diseases. The first maps were published at the beginning of 1942 and two maps have been issued monthly since then with several second editions. These maps are primarily for the use of plant quarantine officers, as they give the world distribution of major plant diseases at a glance, with references to the records on the back of the map.

One of the early casualties of the war was the suspension of the *Kew Bulletin* and we had, therefore, to make other arrangements for the publication of lists of fungi prepared by overseas plant pathologists. No other source of publication being available at the time, it was decided to issue them in *Mycological Papers* in the same format as the *Annotated Accounts of Fungi received at the Imperial Mycological Institute*. These papers have also been useful for the publication of an important work by C. G. Hansford on Foliicolous Ascomycetes.

Another development during the war was the publication of *An Annotated Bibliography of Medical Mycology* annually for 1943 and subsequent years. Previously, abstracts of a certain number of papers on the subject were noticed in the *Review of Applied Mycology*, but some plant pathologists objected to their inclusion and there was no doubt the medical readers were few. Moreover, in editing these abstracts I felt the lack of medical knowledge. The position was surveyed by the Hankey Committee in 1943 and as a direct result the Medical Research Council appointed a Committee on Research in Medical Mycology. With the support of that committee and the collaboration of Dr. C. Wilcocks, Director of the Bureau of Hygiene and Tropical Diseases and Dr. J. R. Duncan, Reader in Mycology at the London School of Hygiene and Tropical Medicine, the *Annotated Bibliography of Medical Mycology* was started. For the first time in this country full collaboration between medical science and mycology has been established, the work of documenting medical mycology put on a firm basis, and the short published abstracts are beginning to reach the public for whom they are intended. By a grant of £15 per annum the Honorary Committee of Management of the Bureau of Hygiene and Tropical Diseases has materially assisted this project.

Another activity of the Institute has been the publication of the *Dictionary of the Fungi* by Dr. Ainsworth and Dr. Bisby, and *An Introduction to the Taxonomy and Nomenclature of Fungi* by Dr. Bisby. Both have been well received and the former has already reached a second edition.

From the beginning of the *Review of Applied Mycology* the indexing of virus diseases has proved a major difficulty for the reason that no internationally accepted system of nomenclature has been devised. Many virologists in this country at least maintain that in the present state of knowledge no basis for a classification of viruses exists and in these circumstances the *Review* has been forced to standardize its usage of the common names of virus diseases and index under such names with the term virus added. The compilation of a list of the names of virus diseases was undertaken by Dr. Ainsworth and a preliminary mimeographed list was submitted to the Special Committee on Virus Nomenclature and Classification of the American Phytopathological Society and to the Plant Pests and Diseases Committee of the Association of Applied Biologists for their comments in 1944. A number of virus authorities at home and overseas also very kindly examined the list and made suggestions;

valuable help was given by all those consulted and has already been acknowledged in the revised list which was printed as a special part of the *Review* and issued to subscribers free of charge in July, 1946. Very considerable support has been forthcoming for this list which it is hoped will exert a stabilizing influence on virus nomenclature.

In 1943 an attempt was made at recording on index cards all papers on systematic mycology coming to our notice, and with the assistance of the abstractors the compilation went on until in 1947 the records for the years 1943 to 1946 were published in mimeographed form. The records noticed during 1947 have been similarly published this year and it is hoped that the publication is of sufficient value to justify its continuance. Dr. Bisby has undertaken the editing of this bibliography.

A very recent publication of the Institute is a tentative *List of tropical plant diseases* issued in mimeographed form last December. This list aims at giving the correct names for tropical plant pathogens and to be a companion list to the *List of common British plant diseases*. Dr. Bisby, the convenor of the Committee of the British Mycological Society responsible for the British list undertook the work though the abstracting staff assisted in supplying the foreign equivalents to the names used. This first list is a tentative one; the British list has taken a quarter of a century to reach its present standard and it is to be expected that considerable revision of this list will be required. Ultimately it is hoped to issue the list in printed form.

Turning now to the identification service which forms the other main activity of the Institute, I would like to refer to important developments in identification technique that have materialized during the last few years. Up till 1945 all specimens identified at the Institute were laid in the Herbarium under the fungus name in the correct systematic position, but no accession book was kept of the specimens and no host or fungus indexes were maintained. Mr. Mason had increasingly felt the need of cataloguing the whole of the Herbarium in order to know what was in it, and in July 1945 when our senior indexer returned from the Land Army an opportunity presented itself of making a determined start on such a formidable enterprise. For 25 years specimens had been accumulating and it was no light matter to start numbering and cataloguing specimens after so long a period. However, a start was made and with the very willing assistance of the herbarium staff, supplemented by several students who have worked for periods in the Herbarium, I am glad to be able to report that the end of the work is in sight. Nearly 30,000 specimens have been listed, a proportion of these have been indexed under the host and fungus, and for many specimens permanent mounts have been filed with the specimen. The technique adopted for sealing microscopic preparations was only discovered after prolonged trials by Major Dade, and I hope some details of this method and others employed in the work will be given on Thursday afternoon. For myself I am satisfied the work is well worth while. We are forging an instrument for the identification of plant pathogenic fungi which may be expected to yield us handsome returns in facilitating the work we have to do.

Within the last year an important development in the work of the Institute was the taking over of the fungus collection of the National Collection of Type Cultures from the Lister Institute. For many years we experienced the great inconvenience of not having a culture collection available for purposes of comparison in identification work and, accordingly, when the Medical Research Council decided to discard the fungus cultures from the National Collection, and we were asked to take them over, we undertook to maintain those of phytopathogenic importance and those taxonomically of interest to plant

pathologists. At the Commonwealth Conference on Culture Collections we were urged to take on other groups and ultimately it was agreed that provided funds were forthcoming we should maintain all fungi excepting timber-rotting fungi (maintained at the Forest Products Laboratory, Princes Risborough), medical fungi, and yeasts. From the beginning of this year we have been supplying cultures on demand. Every culture we have taken over from the Lister Institute has been checked before being incorporated into our collection, and the checking has not yet been completed. The culture collection of the Commonwealth Mycological Institute is regarded as an extension of the herbarium and all the staff assist in the considerable identification work that is necessary. Major Dade has undertaken the supervision of the collection, and he will probably give a talk on the subject on Thursday afternoon.

Apart from the immediate work of the Institute, we are called upon at times to advise regarding disease problems in the Colonial Empire, and it may not be inappropriate if I briefly touch upon some of the matters that have occupied our attention in recent years. At the Third Conference, witches' broom of cacao (*Marasmius perniciosus*) had reached Trinidad and threatened the existence of the cacao industry there. The disease has caused heavy losses, and though unsuitable lands have gone out of cacao cultivation, it is still remunerative to grow cacao in the better areas. Spraying has proved economically impossible but strains of cacao resistant to witches' broom have been discovered in the Amazon basin by Mr. Pound and offer some hope of satisfactory control of the disease in the future. A new enemy to the cacao in Trinidad is a virus disease which it is hoped may be restricted to the northern part of the island. In Jamaica bananas suffered severely from *Mycosphaerella musicola* and upwards of £200,000 has been spent by the Jamaican Government in supplying fungicides and spraying apparatus to enable spraying to be carried out. The timing of sprays has been shown by the brilliant researches of Mr. Leach to be an important factor in efficiency, and the banana growers have now a satisfactory basis for the spraying programme. In Africa cacao swollen shoot developed into an alarming menace and had it not been for the establishment of the West African Cacao Research Institute at Tafo it is likely that the whole of the cacao in the Gold Coast and neighbouring territories would have been doomed. The disease was quickly shown by Mr. Posnette to be a virus disease and eradicative measures have been instituted on a large scale with considerable success, though the magnitude of the task of eradication, with subsidiary problems, still presents administrative difficulties of a serious nature.

Another important disease that has spread into new territory within the last few years is the blister blight of tea, known for many years in Northern India, but now spread to Southern India and Ceylon. The means by which the causal fungus, *Exobasidium vexans*, was transmitted to the new areas is not known, but one can quite easily imagine how such transference took place in view of the disturbances arising from war. By a combination of judicious cultural methods and spraying of nurseries there is some prospect of the disease being kept within bounds, but there is no doubt that the introduction of this single disease will constitute a charge on the tea industry in India and Ceylon for a long time to come.

Among other outbreaks of lesser importance perhaps I may mention potato blight (*Phytophthora infestans*) which developed in East Africa during the war and menaced the native food supplies at one time. Happily one or two native varieties proved resistant and are being multiplied, while the work of breeding others is being actively carried on. A more recent outbreak that threatens a food crop in East Africa is a virus disease of sweet

potato. These are among the outstanding outbreaks of disease in recent years, and constitute the most potent evidence of the indispensable work of the plant pathologist in the production of food. The losses caused to the Empire by plant diseases are enormous and it is only by constant vigilance and endeavour that they can be reduced to permit the economic production of crops.

Apart from the question of disease, however, the attack by moulds and other fungi on fabrics, electrical apparatus, leather goods, optical instruments, and such like proved to be a factor of considerable importance during the war, and in this connexion the Institute has been called upon for information and assistance. Some of us have known for a long time that moulds were responsible for much damage to manufactured goods in the tropics and the *Review of Applied Mycology* has consistently reviewed this work from the start. There is no doubt that the continued investigation of such problems may lead to results of great importance to industry in the future. That firms in this country are alive to the situation is shown by the large number of cultures of test fungi that have been supplied to industry from our culture collection.

Turning now to a matter that affects all who are concerned in the supply of information to scientific workers, I would briefly refer to a development of recent years that promises to play an important part in such work, namely, microfilm. As Director of the Institute I have tried to keep abreast of the application of this method to our work. We have at the Institute a microfilm camera and have had some opportunity of testing the value of this apparatus to us as an information centre. I am satisfied that it promises to be very useful indeed. At present few people have microfilm readers but one hopes the time is not far distant when every plant pathologist will have one in his laboratory. Microfilms are, of course, not nearly so convenient as books, and I believe publishers need feel little concern on that score, but when books are not available, especially reference books, microfilms provide a good substitute and are no more irritating to use than the telephone. We have already microfilmed all the volumes of the *Review of Applied Mycology* that are out of print and have sold a number of copies. I look forward to the time when I shall be able to supply every plant pathologist with all the literature he requires, either by separates lent from our separate collection, by photograph, or by microfilm. I hope to refer to the use of microfilm in mycology again on Thursday afternoon, but could not omit a brief reference to it now.

Finally, I would briefly review the research work done at this Institute, during the last eight years.

Continued progress has been made in the publication of regional floras, notable contributions being Dade's revised list for the Gold Coast, Larter and Martyn's list for Jamaica, Boughey's list for the Anglo-Egyptian Sudan, and two contributions on West African Meliolineae, the first by Deighton and the second by Deighton and Hansford. Lists for Mauritius, Barbados, and Tanganyika Territory are in the press and one for Trinidad in the final stages of preparation. Various papers on Indian Fungi have been published, one series under the leadership of Dr. Watts Padwick and another under that of Dr. Mundkur.

A further instalment of Mr. Mason's *Annotated Account of Fungi received at the Imperial Mycological Institute* appeared in 1941. This special part deals with a number of classical species which had never been described in culture. It is an important contribution to the study of the Hyphomycetes, a group of great phytopathogenic interest.

As a supplement to the work on regional floras, the cataloguing of species already reported for this country has been actively carried on. Mr. Mason

and Dr. Bisby are responsible for a list of British Pyrenomycetes, and Dr. Bisby and Miss Wakefield of the Royal Botanic Gardens, Kew, for a list of British Hyphomycetes, together with a supplement.

Major Dade has continued his special study of *Aspergillus* and checked over all cultures of this group in the National Collection of Type Cultures before that collection came to us. He has also published a valuable paper on 'Colour Terminology in Biology' which aims at standardizing the terms used for defining colour.

Dr. Bisby published a paper on the British Hysteriales giving the final results of his study of the group.

Dr. Ainsworth while he was with us specialized in the smuts and a paper listing a number of species from Uganda appeared in 1941. He also devised a numerical method for characterizing smut fungi which promises to be a useful aid in identification work.

The nomenclature of fungi has given rise to much discussion within and without the Institute and a number of short papers dealing with this subject have been published by Mr. Mason and Dr. Bisby. Mr. Mason in an outstanding Presidential Address to the British Mycological Society dealt with 'Specimens, species, and names'.

Mr. Mason in collaboration with Mr. Hughes and Mr. Ellis has continued the study of the Hyphomycetes and has accumulated considerable information on this group which it is hoped to publish in the next few years. In particular the genera *Torula*, *Monilia*, and *Helminthosporium* have been critically examined. Mr. Hughes has also published papers on fungi attacking sainfoin and on a *Chaetomium*, bringing to fruition studies initiated before he joined the Institute. Mr. Ellis has specialized in the smuts and is monographing the genus *Periconia*.

Miss Waterhouse joined the staff in 1945 and has assisted largely in the editing of the *Review*, but has managed to continue her study of *Phytophthora*, *Pythium*, and other Phycomycetes.

In concluding this survey of the work of the Institute I would take this opportunity of saying how much we are indebted to the Director and Staff of the Royal Botanic Gardens, Kew, and notably to the Assistant Keeper, Miss E. M. Wakefield, for the help they have so generously given us throughout the Institute's existence. The unrivalled collections of fungi in the Herbarium of the Royal Botanic Gardens, Kew, and their most valuable systematic library we are allowed to use to the fullest extent, and this assistance in our work is deeply appreciated.

Finally, I would like briefly to refer to the sad loss mycology suffered in the death in 1943 of the late Sir Edwin Butler, the first Director of the Institute. To the last he maintained his interest in the subject and immediately before his death had engaged in an active correspondence with Mr. Mason on technical matters. Mycologists are indebted to Mr. Mason for the very careful obituary notice of Sir Edwin published by the Royal Society.

APPENDIX II

Commonwealth Mycological Conference, July, 1948

MINUTES OF THE SCIENTIFIC DISCUSSIONS OF THE CONFERENCE

Meeting: Monday, 19th July, 11 a.m.

Chair: Dr. J. C. F. Hopkins.

Discussion: 'Administrative measures against plant disease.'

(*a*) Legislation

Mr. Clay (Colonial Office) said that developments during the last fourteen years, the increased speed of transport, and the initiation and spread of diseases, had made it essential to review the position in regard to the control of the importation of plants, a measure of major importance in disease control. At the same time it was desirable to have an easy transfer of new varieties of plants. The recommendations for an African Phytosanitary Convention drawn up at the Brussels Conference of Colonial Experts were reviewed and it appeared that there would be agreement on many of the points. The need for regional co-ordination and for a permanent centre of information was obvious, and the choice of the Commonwealth Institutes of Mycology and Entomology as possible centres patently suitable. The suggestions for Africa might not be applicable to other parts of the world but at least they would form a good starting-point.

Two major aspects of the necessary legislation were considered to be (*a*) for imports, and (*b*) for suppression of major diseases within the territory. In the South African region there was full co-operation between the different members and the arrangements were working well. The East African scheme needed to be extended to other countries in that region, while other parts outside these areas needed to be organized. However, even where arrangements were satisfactory countries were not always conversant with procedure in other regions.

Mr. Clay considered that maximum measures compatible with minimum public inconvenience were needed and suggested that it was desirable to take steps to set up a permanent commission to review (*a*) plant import legislation and quarantine measures, and (*b*) plant protection legislation.

Dr. Hopkins (Southern Rhodesia) described the plant import regulations and plant interchange schedule operating in the South African region, a summary of which was circulated to the delegates. The restrictions apply only to commercial crops. He said that it was most important to have a convention to exclude from Africa diseases not yet present.

Dr. van der Plank (South Africa) added that in the South African region there was a mutual aid system, each country keeping the others informed. There was free interchange and inspection *inter se* and a common system of imports with three categories, (*a*) unrestricted, (*b*) those needing permits, (*c*) prohibited. Quarantine was considered to be not very necessary because the country of origin was required to give a health certificate, though this procedure did not always work in practice. He suggested that the Pan-African Convention should be on a regional basis as South Africa would not readily give up their present arrangement which was working well.

Dr. Hopkins added that when new regulations were to be made each state consulted the others.

Dr. le Pelley (Kenya) described the co-ordinated arrangements in Kenya,

Tanganyika, and Uganda where permits are required for the importation of any planting material except certain seeds (under 1 lb.), a schedule of non-free seeds being published. Plant imports are restricted to certain ports (including air-ports) and all material is inspected on arrival. Free interchange between the three countries is not practicable because of certain insect pests with a very local distribution. Tanganyika excludes free interchange.

Dr. Hopkins stressed the importance of individual state legislation; each should be free to make its own restrictions. For example, to keep out tomato spotted wilt virus the import of dahlias into Southern Rhodesia from the Union of South Africa was prohibited.

Mr. Trueblood (Nigeria) said that in West Africa few things require a permit. The ill-defined boundaries and unrestricted travel allow free transport of plants to European states. Prohibition of cacao from the American continents, however, has worked well. The Council of Assembly is to overhaul the legislature and tighten up restrictions. The difficulties, however, are that the customs officers are not conversant with diseases and cannot detect them and so stop imports. A trained staff is needed before the regulations can be put into practice.

Dr. Hopkins emphasized the shortage of staff and said that the question of finance would have to be discussed.

The recommendations of 'La Commission Phytosanitaire' made at a Conference of Colonial Experts held at Brussels, 11th–13th December, 1947, were discussed fully; resolutions were proposed and passed to the Resolutions Committee for drafting for submission to the Plenary Session, when they were approved for transmission to the Conference on Continental Quarantine for Africa to be held in London on 2nd August, 1948.

Meeting: Monday, 19th July, 2.30 p.m.

Chair: Dr. G. H. Berkeley.

Discussion: (*b*) 'Seed certification against seed-borne diseases.'

Dr. W. L. Gordon (Canada), in opening the subject, dealt with the importance of seed as a means of disease transmission. Reviewing briefly the growth of our knowledge of seed-borne diseases and the history of their detection, he considered that it might be possible to control these diseases in a more simple and effective manner than those disseminated by other means. Immediate attention, therefore, should be directed to the application of all known practical means of restricting the spread of seed-borne pathogens to avoid further crop losses by them. Bunt of wheat, for example, although detected on seed as early as 1755, still remains a menace to wheat wherever grown.

Representatives of the genera *Albugo* [*Cystopus*], *Peronospora*, *Phytophthora*, and *Plasmopara* have been reported as being seed-borne in one or more of our horticultural plants and of *Sclerospora*, *Plasmopara*, and *Peronospora* in certain of our field crops. Seed transmission in this group of organisms is usually due to survival of mycelium in the seed coat although oospores in some cases may play a part. Members of the genera *Erysiphe*, *Mycosphaerella*, *Pleospora*, *Sclerotinia*, *Claviceps*, *Calonectria*, and *Gibberella* are important seed-borne fungi, their transmission occurring in one or other of the following ways, viz., as conidia or perithecia on the surface of the seed, as sclerotia mixed with the seed, or as an internal mycelium. Among the Basidiomycetes, pathogens which are less commonly seed-borne than the smuts are included in the genus *Corticium* and in the rust genera *Puccinia*, *Uromyces*, and *Melampsora*; these are transmitted largely by surface-borne inoculum, but an internal mycelium

is of the utmost importance in certain species of *Ustilago*. Among the Fungi Imperfecti species of the genera *Ascochyta*, *Phoma*, *Phyllosticta*, and *Septoria* are widely recognized as important seed-borne pathogens particularly of vegetable seeds, transmission taking place by means of pycnidia on the surface of the seed or by an internal mycelium located within some part of the seed. Members of the Melanconiales are usually associated with the seed as acervuli on the seed surface or as an internal mycelium. The genus *Colletotrichum* is noteworthy because of bean anthracnose caused by *C. lindemuthianum*, but other species of this genus are known to be seed-borne as well. Species of *Alternaria*, *Fusarium*, and *Helminthosporium* are commonly associated with the seeds of our vegetable and cereal crops, e.g. *A. brassicae*, *A. solani*, *F. graminearum*, *F. avenaceum*, *F. nivale*, *H. sativum*, *H. avenae*, *H. gramineum*, and *H. teres*; *H. victoriae* must now be added to this list. Other fungi, reported to be seed-borne, include species of *Botrytis*, *Cladosporium*, *Cercospora*, and *Stemphylium*.

Important bacterial seed-borne pathogens include *Corynebacterium michiganense*, the cause of bacterial canker of tomato; *Pseudomonas tabacum*, causal agent of wild fire of tobacco; *Xanthomonas phaseoli* and *P. medicaginis* var. *phaseolicola*, causal agents of bacterial blight and halo blight of beans, respectively; and *X. stewarti*, responsible for Stewart's disease or wilt of maize.

Although seed is generally of less importance in the transmission of virus diseases than of fungi or bacteria, the importance of an occasional virus-infected seed should not be under-estimated. Transmission of the following virus diseases by seed has been recorded: cucumber mosaic, which is transmitted more often by seed of the wild cucumber (*Echinocystis lobata*); mosaic and dot mosaic of lettuce; beet mosaic; bean mosaic; tobacco ringspot, which is commonly transmitted by seed of *Petunia violacea*; potato aucuba mosaic and leaf roll; and tobacco mosaic virus of tomato. The sugar beet curly top virus is found in the seed but is not transmitted to the seedling.

Three stages are envisaged in the process of seed transmission: (1) surface contamination or internal infection, the latter process taking place any time from blossoming until the seed is approaching maturity, and the former either just prior to maturity, or at harvest time, or during subsequent handling or storage of the seed until the time of planting arrives; (2) the hibernation of the pathogen in the seed, which is of interest as it suggests two possible methods whereby the transmission of the pathogen may be hindered or eliminated, either by storage of the seed beyond the period of longevity of the pathogen, or by the application of disinfectants or other means of control to prevent the survival of the pathogen without serious injury to the germinative ability of the seed; (3) the development of the pathogen in its association with the seed from the time of sowing onwards.

The more important factors responsible for the observed variation in the amount of seed infection appear to be the resistance or susceptibility of the host, the amount of inoculum available for infection of the seed, and the amount of precipitation during the growing period, particularly from the time of blossoming until the seed is mature. As seed infection has been found to be generally low in areas with a low total precipitation during the growing period of the crop, it appears that advantage would be gained by producing seed in areas having low rainfall during the crop period. This has been demonstrated by the success achieved in the semi-arid regions of the Western United States in the production of disease-free seed, now becoming an important industry there. Bean seed free from the most serious diseases of this crop is produced in areas where the total rainfall for the four months of the bean-growing season may average less than half an inch. In addition, it has been possible to produce

seed of peas devoid of *Ascochyta* infection, from both naturally and artificially infected seed, when grown in certain areas where the growing period may be rain-free or at most have an average precipitation of less than two inches. Further investigations of possible areas where seed might be produced relatively free from infection are highly desirable.

The period of hibernation of pathogens in the seed may be influenced to some extent by factors such as the individual capacity of different pathogens to remain viable, the physical condition of the seed, and the environmental conditions under which the seed is stored. It is now known, however, that the longevity of many pathogenic fungi, bacteria, and viruses may extend over a period of several years so that the employment of a longer than normal storage period for the seed as a means of eliminating seed infection appears to offer little promise. On the other hand, the possibilities of control of seed-borne pathogens by the application of various chemical or other treatments to the seed during the period of hibernation of the pathogen has long been recognized and considerable success has already been attained by their use. As many seed-borne pathogens, however, have other means of survival and dissemination, besides the seed itself, it may be expected that their complete control will require other means as well.

Although much remains to be learned about the relation of many fungous and bacterial seed-transmitted pathogens to seed germination and further development of the hosts it would appear that, in general, conditions favouring rapid germination of the seed and emergence of the seedling from the soil are least favourable to the transmission of pathogens. Other factors which may influence the amount of disease that develops in a crop produced from infected seed are the amount of inoculum carried by the seed and the resistance or susceptibility of the host.

Recently, evidence has appeared to support the view that there exists on the seed of wheat, and on other parts of the plant, a natural bacterial flora antibiotic to *H. sativum*, and which is considered to be quite different and distinct from the contamination by antibiotic bacteria derived from the soil. Further investigations along this line will be required before the full significance of the relation of a natural bacterial flora on the seed, or of antibiotic bacteria placed artificially on seed, to seed-transmitted pathogens can be properly evaluated. If it should be found that seed transmission of pathogens may be significantly reduced by an antibiotic flora naturally present on the seed or by one placed artificially on the seed previous to the time of planting, some attention might well be directed towards the effect on such a flora of chemical or other types of seed treatments.

Losses due to seed-borne pathogens may arise from a severe reduction in germination, from death of the seedlings before they emerge, or at some point in their subsequent development prior to maturity. These are 'primary' losses but they may not be serious when the rate of seeding is greater than necessary for the maximum yield. 'Secondary' losses may result from spread to adjacent healthy plants, and the importance of taking all possible precautions to avoid the planting of infected seed when even a small percentage of it is carrying viable pathogens should be emphasized. For instance, the planting of beans, with only the occasional seed carrying viable *X. phaseoli*, may result in disaster to the ensuing crop because of the rapid spread of bacterial blight.

Other types of losses are the poisonous effects produced by the seed-borne pathogens, e.g. *Claviceps purpurea* and *F. graminearum*, and the offensive odour of wheat seed contaminated with bunt spores necessitating washing before it can be used in flour-making. During the 32-year period, 1915–46,

the average annual discount on 'smutty' wheat originating in Western Canada has been conservatively estimated at approximately $125,000. The monetary loss associated with the treating of seed as a control measure must be included in the category of losses due to seed-borne pathogens.

Professor Muskett (United Kingdom) dealt mainly with three techniques used in the examination of true seed for seed-borne parasitic fungi. He expressed the opinion that plant pathology could offer no greater contribution to our general agricultural and horticultural well-being than in ensuring the health of standing crops; all seed and planting material should be of first quality and the ideal to aim at would be the production of trouble-free seed and planting stocks. Ancillary measures such as seed disinfection would also be of great assistance in striving for this objective.

Techniques for examining seed for seed-borne fungi should be rapid and simple, as well as accurate, in order to keep down the cost of examining thousands of seed samples. When devising such techniques the fact should be borne in mind that they are to be operated mainly by trained laboratory assistants; they should bear as close an alliance as possible to the techniques of seed-testing stations.

Methods were described for examining seed oats for *Helminthosporium* (*Pyrenophora*) *avenae*; the seed of flax for various fungi including *Colletotrichum linicola*, *Polyspora lini*, *Botrytis cinerea*, *Phoma* spp., *Fusarium lini*, *Alternaria tenuis*, and *A. linicola*; and rye grass for *Phialea temulenta*.

In the case of *H. avenae*, reliable results are obtained when 15 oat seeds are incubated on damp filter-paper in Petri dishes at 22° C. for 3 to 4 days and then exposed (the lids of the dishes having been removed) to ultra-violet light for 20 minutes. Such exposure stimulates the production of conidia by the fungus. After further incubation for some 5 to 6 days the material is examined at a magnification of × 60 and a positive result recorded only when a typical conidiophore with one or more conidia *in situ* is seen. Over a number of years the application of this method has proved most successful.

The 'Ulster' method for the examination of flax seed by plating out 10 seeds on 2 per cent. malt agar in each Petri dish (9 cm.) and incubating at 22° C. for 5 to 6 days was devised for *C. linicola* and *Polyspora lini*. It was later found to be applicable for *B. cinerea*, *Phoma* sp., *F. lini*, *A. tenuis*, and *A. linicola*. Colonies of the different fungi growing out from the seed on to the malt agar are readily recognized by their characteristic macroscopic growth characters.

For detecting the presence of *Phialea temulenta* on rye-grass, the seeds are placed in water after the removal of one or both glumes. Conidia of the fungus float out into the water from contaminated seeds and are readily seen by microscopic examination (× 100). This method does not show whether the fungus is viable, and to determine this another test in which surface-sterilized caryopses are split and plated out on malt extract agar is employed. If present, the fungus grows out into the medium and can be readily recognized.

The techniques described have been of value in seed sorting and in the testing of disinfectants. By this means 'nomersan' was shown to be useful in disinfecting fibre flax seed for the control of *C. linicola* and to a limited extent for *Polyspora lini*. By such disinfection some £2,000,000 worth of flax fibre was saved during the war period.

The presence of fungi on seeds often gives some indication of the locality where the seed was produced. For example, *Alternaria* spp. are frequently contaminants of flax seed produced in Canada, *C. linicola* occurs on seed produced in the north and west of the United Kingdom, and *P. lini* and *Phoma* sp. show a rather similar behaviour. *B. cinerea* occurs regularly in all districts, and rust (*Melampsora lini*) is most prevalent in south-east England.

Mr. Conners (Canada) asked if rust detritus could be detected on the seed.

Professor Muskett replied that it could.

Professor Malcolm Wilson (Edinburgh University) suggested that the reason why more rust occurred in south-east England was because the spores were more likely to mature there than elsewhere.

Mr. W. C. Moore (United Kingdom) said that, apart from routine certification of seed for export, very little had been done in England and Wales in the way of seed certification against disease. A good deal of interest had lately been created in the subject and he wished, in general terms, to mention a few possibilities.

As far as seed certification for export was concerned, the requirements of importing countries are met as far as possible by examining samples of seed to be exported and certifying that they 'were found or believed to be free from injurious plant diseases and dangerous insect pests'. Examination is carried out at the Ministry of Agriculture's Plant Pathology Laboratory at Harpenden. Samples are drawn from the seed stocks to be used in making up the order, sent to Harpenden, examined, and a report forwarded to the Ministry's Horticulture Branch, which issues a health certificate.

Such examination obviously has distinct limitations. Seed cannot be certified as free from those diseases, such as loose smut of wheat, black rot of crucifers, bacterial canker of tomato, and bean mosaic, which cannot readily be detected under a binocular microscope or by a rapid and simple method involving germination or examination of washings. They could and did to a large extent, however, prevent the more easily recognized diseases from being exported with seeds. Of 33,000 seed samples examined during the last 23 years, about 2 per cent. had been rejected on grounds of disease. On the other hand, nearly a third of the samples of pea seed examined were rejected because of *Ascochyta*, nearly half of the celery samples because of *Septoria*, and it was comparatively easy to detect seed substantially infected with halo blight and anthracnose of dwarf beans, or contaminated with ergot, the sclerotia of *Sclerotinia sclerotiorum*, and certain other parasites. Stricter standards would be possible, he said, as and when field certification of home-grown crops was developed.

At present, seeds of all kinds can be imported freely into England and Wales without a certificate of health. If special efforts were to be made to raise the health standards of home-grown seed, precautions would have to be taken to ensure that imported seed did not bring in disease as it had done in the past. There could be no reasonable doubt that bacterial canker of tomato (*Corynebacterium michiganense*) was introduced into England with infected seed during the war. It is rarely easy to trace the origin of new diseases because they often spread fairly widely before attracting attention; he suspected that *Alternaria* blight of tomato came in with imported seed four or five years ago.

As pre-war seed imports into the United Kingdom amounted to nearly 30,000 tons valued at over £1,000,000, the import situation obviously needs watching, the more so as air transport develops. This can perhaps best be done by a demand for a health certification by the exporting country, as is already required for nursery stock and other living plants, or by the setting up of a committee or quarantine board at this end, or, indeed, by both methods.

The question of certifying home-grown seed is an important one for the immediate future. At present the routine testing of seeds at the Official Seed Testing Station, Cambridge, is concerned only with purity and germination, though in the reports issued reference is made to the incidence of diseases, such as bunt of wheat and ergot of cereals and grasses, which can be detected

by naked-eye examination. Special examination of celery seed for *Septoria* is undertaken there.

In 1942 the Ministry's Seed Production Committee was established. This Committee took over the supervision of certain Field Certification Schemes for wild white clover, perennial rye grass, and herbage plants, and it has since instituted new improvement schemes for seed production of cereals and peas. It was pointed out that these schemes were concerned primarily with purity of the seed, though some attention is now being given to diseases. A start has been made by introducing tolerances for bunt, &c., in the certification of cereal crops, and for *Sclerotinia* in certifying clover and sainfoin. It seems that through these schemes much could be done in the way of certifying seed free from disease, especially for diseases that demand field inspection. He thought that one of the first steps might well be the appointment of a mycologist to the staff of the Official Seed Testing Station at Cambridge. Seed certification schemes were unlikely to prosper without close co-operation at all stages between the plant pathologist, the administrator, and the seed trade.

The need for comparative examination of seed samples drawn from different geographical areas was stressed. The incidence of diseases varies greatly with the district, and carefully conducted surveys should give valuable information about the best parts of the country in which healthy seed crops could be grown. There is also need for a small, up-to-date handbook listing the known seed-borne diseases, and summarizing laboratory methods of testing for them as well as appropriate methods for dealing with them.

Dr. Hopkins (Southern Rhodesia) endorsed the suggestion that mycologists should be appointed to seed-testing stations. Field inspection is more important in the colonies where laboratory facilities are non-existent.

Dr. Dennis (Royal Botanic Gardens, Kew) laid stress on the fact that a mycologist, not a plant pathologist, should be appointed.

Mr. Conners (Canada) said that in Canada it was difficult to get firms to co-operate because of the cost of seed testing.

Professor Muskett considered that this was more than covered by the benefit gained.

Dr. Berkeley also thought that the cost would take care of itself.

Dr. C. E. Foister (United Kingdom) described the work of the three sections of the Station of the Department of Agriculture for Scotland at East Craigs, Corstorphine, Edinburgh, showing the liaison between them with special reference to seed-borne diseases. The three sections are under one roof: the Scottish Seed Testing Station, the Plant Registration Station, and the Plant Pathology Service; close association has proved of benefit to each of them. The Seed Testing Station operates under the terms of the main Seeds Acts 1920 and the Seeds (Scotland) Regulations 1922, and its functions are to test and report on the purity, germination, and vigour of seeds submitted by the seed trade and farmers. The Plant Pathology Service provides a scientific background for the Government's schemes and regulations aimed at the commercial control of plant pests and diseases. As a direct result of liaison between the departments, marsh spot of pea is now reported by the Seed Testing Station under the category of broken seeds, whereas prior to co-operation in 1937 the disease had passed unrecognized. The Plant Registration Station carries out trials of new varieties of certain agricultural plants with a view to the registration of those which reach a high standard in commercial qualities, coupled with resistance to certain diseases. For example, new potato varieties immune from wart disease, blight, and certain virus diseases have now been registered. It is hoped that the disease-resistance factor will be included in the future trials of other crops, e.g. oats and grasses. Certification schemes are linked

with the work of all three of the above sections, but are administered by the Department's Inspectorate. The main objectives are (1) the detection and prevention of seed-borne diseases amongst home-produced crops, and (2) the prevention of import and export of infected seeds. The requirements for achieving these objectives are: surveys to discover the diseases present which are of economic importance both in crops and seed consignments; research on the causal organisms, their pathology, and their control; routine testing of seed to check how far the growers are gaining control of the diseases in the field; and certification and registration schemes to provide for the production of cleaner crops and the raising of disease-resistant varieties.

In Edinburgh a start has been made towards these objectives. Regarding surveys, an attempt has been made at East Craigs to determine the range, frequency, and severity of seed pathogens of peas, oats, wheat, flax, and swedes; really serious work, even on one crop, is not possible, as no special staff for this work is available. Work is now restricted to cereals by arrangement with the Plant Pathology Laboratory at Harpenden, where vegetable seeds are being specially studied. It is found that the best method is to obtain from the Seed Testing Station samples selected so that the results of a laboratory test can be correlated with the development of the crop in the field.

The terms of the previously mentioned Acts do not require the determination of diseases other than those obvious to the naked eye, such as bunt, ergots, and sclerotia. Any determination of seed-borne disease by the pathology section can be carried out only on an advisory basis and a limited number of such tests are made on the special request of a few seed merchants and farmers. The methods used are: (1) visual examination, which is of restricted use; (2) Copenhagen tests; (3) a variation of the Hiltner test using sand; and incubation on (4) damp filter pads or (5) culture media. For some diseases a combination of several methods may be required. The determination of *Phoma lingam* on swede seed cannot be made under four weeks, especially when *Alternaria* is present. In testing seed intended for export, it is considered that the longer period necessary to test the seed properly by the methods just mentioned is justified; this may lead to complications, as some seedsmen expect a report almost immediately, and submit samples only a few days before the consignment is scheduled to leave port. While no regulations cover imported seed this is sometimes tested and one example of an imported seed pathogen is *A.* [or *Stemphylium*] *radicina*, which was introduced for the first time into Scotland from the United States in 1943. A solution to the question of how to pass information on seed pathogens to the growers is urgently necessary and it seems that an advisory service would be welcomed by the seed trade and the growers.

The use of certification schemes, whereby élite stocks of approved varieties of potatoes, cereals, or other crops grown for seed are produced under high standards of purity, cultivation, freedom from diseases, and in good isolation, demands that full information is obtained on the pathology side, especially as regards the maximum tolerances for the different diseases, their distribution, and rate of spread, in order that such schemes be founded on precise scientific data rather than on empirical observation. The plant pathology section at Corstorphine has been required to investigate the disease aspect of a possible oat certification scheme, a trial of which is in operation this year. Determination of the presence of diseases is simple compared with the determination of safe maximum tolerances to be allowed either in test plots or in the field. Experience of colleagues overseas, and in this country, in other cereal certification schemes will be of great value here. The oat crop is doubtless the first cereal to be selected for two reasons, it is Scotland's largest crop by acreage

and serves as a major supply of seed oats to England. The impact of foreign certification schemes and the relation of imported foreign varieties to registration should also be considered, especially as these imported varieties are not necessarily resistant to diseases in this country.

Mr. Brett (Cambridge Seed Testing Station) said that initial amateur surveys have shown that these are valuable for giving some indication of the incidence and spread of diseases. There appears to be hope for the appointment of a mycologist whose services would be valuable for checking the tests at present used, for initiating new projects, for carrying out surveys, and starting a new service for seed certification. The latter is at present limited by the Seeds Act, but although it is not possible at present to certify concerning diseases it is possible to add further information. The schemes in operation at present certify the crop, not the seed, and define varieties, stock, and field inspection standards. The inspection scheme for cereals is focused on the raising of the standard of purity and ensures that the buyer can get seed of certain purity and also free from certain diseases. A cereal seed crop inspection scheme of a national character was first formulated in 1946 by the Seed Production Committee of the National Institute of Agricultural Botany and in 1947 was revised and extended. The scheme is now operated by seed growers associations and by approved seed merchants. This year some 80,000 acres are likely to be inspected. Attention has been directed to the loose smuts, where the standard is 1 infected head per 10,000 (1 per 5,000 for 3 susceptible varieties), and to bunt and covered smuts where it is 1 per 20,000. The scheme has operated for one year only, covering some 20,000 acres inspected. If standards were higher stocks would be reduced. They can be revised in the light of experience and raised. Disease-free stocks are noted.

For herbage crops *Sclerotinia* in clover has been covered. Rejection is based on the percentage of dead plants in the crop. Above 10 per cent. dead the seed crop is rejected. For celery the trade is agreeing to pay growers a bonus for seed certified as free from *Septoria*. It is appreciated that field certification is only a beginning. Growers see the need for expansion to cover a wider range of seed-borne diseases.

Dr. Gordon (Canada) said that there was blanket seed treatment of certain cereals in Canada, where oats and barley, for example, were automatically treated. He asked if anything of this nature was operating in Great Britain.

Professor Muskett replied that during the war compulsory treatment for oats was offered by his Government, but the Pathology Department refused. They preferred to obtain the co-operation of the growers. The project was put to them and they agreed to do it voluntarily. An agreement was also reached for flax in Northern Ireland in 1940. Britain followed suit with flax treatment the following year. All seed from Canada was disinfected with nomersan last year. He concluded by asking if ceresan or organic mercurials were considered to be better than nomersan in Canada.

Mr. Conners thought that ceresan was equal to nomersan and that the seed treatment of fibre flax was increasing in Quebec.

Dr. Gordon said that ceresan treatment had been found useful in Canada; *Colletotrichum lini* was not important there.

Professor Muskett maintained that the same treatment for flax and cereals was not satisfactory, and to this Dr. Gordon agreed.

Dr. McKay (Eire) asked if pasmo disease of flax was controlled in Canada.

Dr. Gordon replied that it was kept down.

Professor Muskett emphasized that the treatment must be *specific* for each disease.

Mr. Samuel (United Kingdom) said that there was a campaign for the

treatment of all cereal seed in England and asked if blanket treatment was recommended in Canada.

Dr. Gordon said that they were now coming to that in Canada for wheat and oats.

Mr. Conners maintained that it is more profitable to treat than to test.

Dr. Gordon thought that disease should be cut down to a minimum as an insurance to growers.

Professor Wilson (Edinburgh University) felt that more mycological work is needed on seed-borne diseases, information being required on life-histories and the methods by which seeds become infected. He cited *Phoma lingam* as an example of a common disease where the method of infection is unknown.

Dr. Watts Padwick (Imperial Chemical Industries, Ltd.) doubted the value of certification unless the amount of inoculum which can be tolerated is known.

Dr. Mary Noble (Edinburgh) described how seeds from good fields all over Scotland are tested in the laboratory as well as in the field.

Dr. Cunningham (New Zealand) pointed out that seed dressings aid the emerging seedling and that this is an added benefit.

Dr. Berkeley summed up the two main points emerging from the discussion: (1) that the schemes are progressive; new ones improve in effectiveness and standards rise; (2) a mycologist or plant pathologist, or both, is necessary at seed-testing stations. Dr. Brett was asked to formulate a resolution to cover the second point for submission to the Conference at the concluding session (see Resolution 3).

Meeting: Tuesday, 20th July, 10 a.m.

Chair: Mr. Bawden.

Discussion: 'Control of virus diseases. (*a*) Swollen shoot disease of cacao.'

Mr. Robertson (West African Cacao Research Institute) gave a brief account of the scientific work on the diseases being carried out by himself and his colleagues of the Pathology Division of the Institute. No exaggeration, he said, can do justice to the seriousness of the disease. In the Eastern Province of the Gold Coast, one of the main producing areas, there are about 300 square miles of dead cacao and a belt of about 200 square miles around this area through which the disease is advancing and killing the trees. While the national effect is serious the local effect is catastrophic. Cocoa-buying centres which at one time handled a thousand tons of cocoa in a season, now handle only a few and there is no doubt at all that many people have suffered severely from the effects of this disease on their income.

The stem swellings by which the disease was first recognized are not always the most conspicuous symptoms, and the chlorotic patterns on the leaves are most generally useful for diagnosis. It has been found that seedlings of the West African Amelonado cacao are genetically fairly uniform and react consistently when inoculated with the virus of swollen shoot. Thus it has been possible to show that samples of inoculum collected from different areas in the Gold Coast, Nigeria, and the Ivory Coast produce distinct symptoms when inoculated to Amelonado seedlings. Later work has demonstrated that these variants are frequently distinct viruses showing no protection in cross-immunity trials. Todd has shown, moreover, that these viruses can be differentiated by the sequence of symptoms they show in the growing cacao plant.

Inoculated seedlings, which flush more frequently than mature cacao, show a very obvious shock reaction and this and the sequence of symptoms in succeeding flushes varies from virus to virus and, to a lesser degree, from strain to strain. As an example, virus A shows a 'fine grain mosaic' caused by localized clearing of the minute vein reticulum and a down curling of the leaf edges in the first symptom-bearing flush, and in succeeding flushes a gradual localization of the clearing to the areas of the main veins to give a 'fern pattern'. Virus M, on the other hand, after the shock reaction, which is distinct from that of virus A, produces no further symptoms for four or five flushes, although the virus may be recovered from some of these symptomless leaves; then the shock reaction appears again.

An interesting point about these viruses is their geographic separation, which is clear cut. Virus A, the virus of the Eastern Province, has caused the largest part of the damage so far and in comparison the others are mostly mild viruses, though they are capable of doing a great deal of damage. In the cross-protection tests it has been shown that attenuated virus A from the Eastern Province, strain H (Dawa, E.P.), and strain K (Konongo, Ashanti), confer complete protection against virus A. Strain B (E.P.) confers incomplete protection against virus A, while virus C (Kpeve, Togoland), D (Nkawkaw, E.P.), E (Pamen, E.P.), F complex (Western Province), G (Dochi, E.P.), J (Bosumtwe, Ashanti), M (Mampong, E.P.), N (Akanran, Nigeria), 01, 02 (Olanla, Nigeria), and 03 (Ilesha, Nigeria) confer no protection against virus A.

Virus A, which has been studied most thoroughly, spreads from tree to tree, so that an outbreak beginning with one tree spreads radially and eventually in an amoeboid pattern. So far as our observations go this is also true of the other viruses. The rate of spread in the early days is relatively slow, but as the perimeter of the outbreak increases more trees will become infected in any given space of time. Thus the percentage infections of 234 trees by the Dawa strain (H) in the four years (1942–6) were 2·1, 6·8, 14·5, and 81·6. In the area of mass infection in the Eastern Province simple radial outbreaks become obscured by the starting up of adjacent outbreaks.

The nature of the spread of the disease is determined by the behaviour of the vectors, which are all Pseudococcids. Strickland has shown that by far the commonest of these vectors in cacao at Tafo is *Pseudococcus njalensis*, and it has been shown by Posnette to transmit all the strains except one from Asalu. About 99 per cent. of the mealybug population of cacao consists of this insect. *P. citri* which has been shown to transmit strains A, C, D, F, and M, *Ferrisia virgata* which transmits A, B, F, J, K, 02, and 03, and *P. bukobensis* and *P. longispinus* make up the remaining one per cent. Adult mealybugs do not move about much unless disturbed, but the first and second instar larvae and nymphs are active. The crowns of cacao trees are completely interlaced and young mealybugs can pass easily from tree to tree. *P. njalensis* and to a lesser extent the other mealybugs are attended by ants which foster the colonies and build tents of earth over them. They may be effective in distributing the mealybugs for short distances.

The viruses so far tested behave in the mealybugs in a manner intermediate between the persistent and non-persistent viruses as defined by Mrs. Watson. On prolonged starvation the insects become non-infective after a period of 36 hours. I have found that when moved from plant to plant at half-hour intervals they are occasionally capable of infecting two plants in succession, but have had no indication of any further persistence. Mealybugs can infect a healthy plant after 'feeding' for 20 minutes, much of this period being taken up by settling and penetration. On the other hand, the starved mealybugs do not immediately become infective when feeding on a virus source, the

infection rate increases with time of infection feeding on leaves, during the first ten hours. Vector-virus studies have been greatly aided by Posnette's development of the bean-feeding technique; a dissected cacao bean, consisting of one cotyledon and the radicle, is enclosed in a block watch-glass with a glass cover. The insects settle and feed readily in the folds of the cotyledon. The length of time between infection and the showing of symptoms has been reduced by this method from about 3 months to about 20 days. Also a ready supply of homogeneous test plants is always available.

The swollen shoot disease described is a disease which under orchard conditions at home would be readily controlled. The spread of the infection is restricted to neighbouring trees and symptoms show up generally in three months after infection. The efficacy of cutting out has been fully demonstrated by experiment at Tafo. Of 341 outbreaks only 17 have given recurrent infection after treatment, and for these anomalies it is believed that wild hosts may be the source of infection. Moreover, in 80 acres of good cacao at the Station only 677 trees have been lost since 1939, in an area which is surrounded by diseased trees.

The control of the disease has recently become tied to the political troubles, and although cutting out of diseased trees appears to be the most effective and the cheapest method of control, all possible lines which might lead to an alternative method are being pursued.

In the beginning of the work about 500 clones, which were established from apparently healthy cacao trees in the midst of disease outbreaks, were tested by grafting to virus A infected material. About 50 which did not immediately succumb to the disease were then tested by back transmission to healthy saplings and they were found to fall into two categories. The first of these yielded the severe virus and were clearly tolerant carriers; the second yielded a very mild virus which Todd calls attenuated virus A. Virus A commonly occurs as a mixture of strains of varying severity and these attenuated strains occasionally turn up in insect inoculations. The clones which tolerate the severe virus have been propagated at Tafo and are at present being yield recorded. The early indications are that they are not so vigorous as healthy plants and show a slow deterioration. Plants inoculated with the attenuated virus show immunity from virus A and they seem to be as vigorous as healthy trees, but we have no data on the ultimate effect on vigour and yield or of the stability of such viruses when present in large mass in the field. These questions are being investigated.

It might be thought that the control of a slow-moving vector by spraying or fumigation could be an answer to the problem. From Strickland's studies it does not appear that such spraying would be practicable. The populations of mealybugs are never large and they are scattered in the crowns of the trees and are difficult to get at with sprays. The possibility of chemotherapy against the disease has not yet been tackled. The research work on the problem has had to await a more detailed knowledge of virus-vector relationships and more control of infection in the laboratory. The subject is now being pursued.

So far the straightforward aspects of the disease have been dealt with; there are two complications. These are of small importance while the great mass of potential infection still exists in the Eastern Province, but they have to be considered in any long-term policy for the control of the disease. The first complication is the occasional dispersal of young mealybugs by strong gusts of wind. About 15 per cent. of crawlers, under optimum conditions, are capable of infecting a plant, and some of them retain this power of infecting after being starved for 36 hours. Where infected trees are only occasional wind-blown mealybugs can be responsible only for the initiation of a few new

outbreaks, but where there is a large block of infected trees surrounded by healthy trees the ones on the leeward side will be subjected to a continual hail of infected mealybugs and new foci of infection will be continually advancing into the stand of healthy trees.

The second complication is the presence of alternative hosts of the viruses. The first progress towards the elucidation of the alternative host problem was made when Todd found symptoms resembling those of nearby cacao viruses in a coppiced plant of *Cola chlamydantha* near Wiawso in the Western Province. Transmission by insects from this plant to cacao was obtained at Tafo. Later expeditions, when field transmissions have been made, showed that as many as 30 per cent. of the *C. chlamydantha* in the field are infected. Todd is still investigating the distribution of diseased *C. chlamydantha* in the field; infected trees have already been found in a forest reserve comparatively remote from cacao trees and there is every indication that this plant is the natural and the most important host of the virus in the Western Province. We have not been able to find any field hosts of the other viruses so far, and although we believe they must exist it is clear that they are of little danger compared with the infective cacao itself. The method now used to try to find these alternative hosts is by attempting to infect very young seedlings of suspected tree species using enough mealybugs to give more than 90 per cent. infection in the cacao controls. Back transmissions to cacao are done at intervals. In this way, providing the insects feed well, it can be said with certainty whether a tree species can become infected or not. So far the following have been infected: *Adansonia* (with viruses A and C and, to a lesser extent, M), *Bombax* (A), *Ceiba pentandra* (A, F, Offa Igbo, and, to a lesser extent, M), *Sterculia rhinopetala* (C and M), *S. tragacantha* (M for five weeks only), *Cola chlamydantha* (F), and *C. cordifolia* (A, F, Offa Igbo, and, slightly, C). Symptom expression, duration of infection, and virus concentration in these hosts appear to be very varied and render field work difficult.

Mr. Paine (West African Cacao Research Institute) dealt with the history and control of swollen shoot disease of cacao. He described its advance in the Gold Coast from the time when it was first noticed in 1932. The 200 acres infected in 1939 were devastated by 1945, the infected area had increased by 150 acres, and the disease had spread to other provinces as well as to neighbouring countries. The rate of mortality had risen from an average of 5,000,000 trees per year in 1945 to 15,000,000 in 1946 and it was estimated that a further 46,000,000 would die during the next two years. The production in 1946–7 was down by 108,000 tons valued at nearly £6,500,000.

After reviewing the earlier attempts at control Mr. Paine gave details of the cutting-out treatments adopted in 1940 after the recognition of the virus nature of the disease by Posnette. The campaign was pursued vigorously from 1941 to 1943, work being concentrated on the outskirts and infected areas, and large areas with isolated outbreaks were freed from the disease. After a suspension of the work, treatment was resumed in 1946 with the consent of the farmers, but in view of the speed required, early in 1947 the Government undertook control backed by legislation. Outlying areas were treated first and then new farms springing up in the centres of old infected areas, thus isolating a strip of badly infected adult cacao known as the 'raging belt'. The eradication of this belt, which was to have been completed in 1948, was halted by lack of staff and by political troubles. Meanwhile only a few farms are being treated on a reintroduced payment system and the disease has recommenced its advance into a belt previously freed.

The efficacy of the cutting-out treatment on the lines described is unquestioned and the state of the trees at the Cacao Research Station, Tafo, is a

remarkable tribute to its success. Although situated in the heart of the 'raging belt', it stands out as a patch of healthy cacao in a wilderness of dying farms. Sporadic outbreaks occur frequently but are as frequently controlled and the areas are successfully replanted. Further examples of the successful control of outbreaks in Kwabeu, Kwahur, nearly the whole of Ashanti, and in the good cacao in the Eastern Province were given. This treatment, proved effective, can be continued only if political disturbances allow it.

Professor Baker (Trinidad) gave an account of the Trinidad cacao virus which is of very minor importance compared with the swollen shoot virus complex in the Gold Coast. The disease is confined mainly to the western end of the Northern Range with smaller diseased areas on the corresponding northern slopes. A small outbreak near Sangre Grande, which was traced to the use of cuttings taken from diseased trees, has been eradicated. The whole diseased area is therefore a compact one and is fairly remote from the main cacao-growing areas of the island.

It was originally suggested that an attempt should be made to eradicate the disease from the island by felling all diseased trees, their contacts and, if necessary, the whole of seriously diseased fields. Mainly owing to opposition from the planters, who did not consider the disease sufficiently serious to warrant the wholesale destruction of their cacao estates, especially at a time when the price of cacao was high, the scheme was abandoned. Other factors against it were the expense, the lack of an alternative crop, and the fact that it was impossible to forecast the outcome of such a scheme when little or nothing was known about the alternate hosts of the virus or about its vectors.

It was therefore decided to try and isolate the diseased area from other cacao-growing areas. This scheme is considerably simplified by the fact that the diseased area is in the north-western corner of the island, but is complicated by the presence of the main cacao-propagating station within it. In an attempt to protect this station from infection a cacao-free belt one mile wide has been cleared all round it and the nurseries are subjected to frequent routine inspections. Although no case of virus has ever been found in the nurseries, or on plants propagated from cuttings from these nurseries, it is realized that the position is not entirely satisfactory and that some risk remains.

It is hoped that it will shortly be possible to establish a cacao-free belt of country, at least three miles wide, between the diseased area and other cacao-growing areas of the colony. Cacao virus is not at present a notifiable disease. All likely foci of infection were searched in 1945–6 and a few infected plants destroyed. There is no organized search to spot new outbreaks except on the borders of spreading areas.

In co-operation with Professor T. W. Kirkpatrick recent work in the laboratory has been mainly concerned with the search for vectors, using the seed-dissection technique devised at Tafo. Three species of Pseudococcinae found on cacao have been proved to be vectors. One is probably *Ferrisia virgata* and the others may be *Pseudococcus citri* and *P. brevipes* and there is probably no difference in efficacy between these three vectors or between the second or third stage nymphs or young adults. There is no indication that starvation before feeding on the source plants is essential, but starved bugs feed much more readily, 18 to 24 hours being enough for this purpose. The minimum feeding-time that has so far resulted in positive infections is 45 to 60 minutes. All indications are that $2\frac{1}{2}$ to 3 hours is the minimum time to ensure that a good proportion becomes infective. The incubation period in the plant is usually 20 to 26 days, but 72 out of 103 have shown symptoms in 25 to 44 days.

Field observations at River Estate have confirmed an earlier impression

that strain A at least is capable of causing both damage to the trees and loss of crop.

In reply to a question from Mr. Bawden (United Kingdom) Professor Baker said that the viruses in Trinidad and the Gold Coast had not been compared; Mr. Robertson pointed out that Posnette considers that the Trinidad forms resemble some of the wild strains in West Africa.

Dr. van der Plank (South Africa) asked if the increase in West Africa were due to infection from natural hosts; if this were the case there should be scattered outbreaks.

Mr. Robertson said that in the case of virus A, which was the most important strain, the virus spread rapidly, destroying the trees. There might be some infection from wild plants, but it was sporadic.

Mr. Robertson, in reply to a question from Mr. Bawden, said that some wild hosts were more susceptible than others.

Dr. Keyworth (East Malling) asked if it were possible that differences were due to different strains of cacao virus and not to different viruses.

Mr. Robertson said that different varieties of the tree reacted in the same way to the same virus, and that there appeared to be several different viruses.

Professor Baker pointed out that symptom differences are very marked in different clones and they can be recognized by the different symptoms.

(*b*) 'Stone fruit virus diseases in Canada.'

Dr. Berkeley (Canada) gave an outline of the work being done in the Dominion Plant Pathological Laboratories at Summerland, B.C., and St. Catharines, Ontario, on virus diseases of stone fruits. The information on the British Columbian virus diseases is from the work of McLarty, Lott, and Welch of the Dominion Service and Foster of the Provincial Department, while that on the Ontario diseases is from Willison and Berkeley.

Up to 1940 the only known virus diseases on stone fruits in Canada were peach yellows and little peach in Ontario and mottle leaf in British Columbia. During the past eight years 13 new virus diseases have been discovered in these two Provinces, though at least three or four of these were present for some years without their virus nature being suspected. This is true of peach X-disease and cherry yellows in Ontario and little cherry in British Columbia.

Little cherry on sweet cherries is the most serious disease and has spread rapidly. In a number of districts 100 per cent. of the trees are affected. Symptoms are confined to the fruit, which is about half the normal size, angular in shape, and retains the bright red colour of immature cherries far beyond the normal picking date.

Cherry yellows on sour cherry causes a yellow leaf condition and casting of leaves about three to four weeks after petal fall. It reduces the crop up to 50 per cent. in trees affected for three or more years. Sweet cherries react to inoculations with cherry yellows by expressing a mild mottle or may be practically symptomless though carrying the virus. Every case of yellows so far investigated appears to be associated with necrotic ring spot virus.

Necrotic ring spot on sour cherries can be diagnosed in the orchard only when trees are in the early stages of infection, there is a definite delay in foliation and early formed leaves show chlorotic spotting, necrotic etching, and, later, shot-holing. After these initial shock symptoms the trees recover and no further symptoms occur and the only sure way then to ascertain whether a tree is infected is to index on peach, Italian prune, or healthy Montmorency sour cherry. Sweet cherries may show mild mottle or no symptoms.

Prune dwarf on Italian prune is uncommon in Ontario. Affected trees show narrow, strap-shaped leaves, with roughened surfaces and are useless as only a few fruits develop, though these appear to be normal. Sweet cherries may show mild mottle or no symptoms.

In the case of tatterleaf on sweet cherry the leaves become mottled, distorted, and necrotic, ultimately becoming shredded or tattered. The symptoms of this disease on sweet cherry resemble somewhat those of necrotic ring spot on sour cherry though cross inoculations indicate that they are distinct diseases.

Peach X-disease is present in both Ontario and British Columbia, the western disease being called western X and the eastern one eastern X-disease. In Ontario X-disease is apparently spread from choke cherries (*Prunus virginiana*) to peach with little or no spread from peach to peach. In British Columbia, however, the spread from choke cherry (*P. demissa*) to peaches is not so evident but readily takes place from peach to peach. In Ontario on choke cherries the symptoms in the first year consist of brilliant yellow to red coloration. In the second the leaves have a duller colour and shoots become rosetted. In the third or later seasons affected trees die. On peaches in British Columbia or Ontario the first symptoms are yellow to red spotting, chlorosis, necrosis, shot-hole, and casting of affected leaves with the tip leaves for the most part being unaffected. Affected trees soon become unprofitable and in Ontario must be removed. Recently, in New York, Parker and Palmiter have shown that the X-disease virus causes a wilting and death of Montmorency cherry trees.

In addition to the above six important diseases there are several others of lesser importance, in so far as distribution is concerned, though infected trees may be seriously affected. In British Columbia these are Lambert mottle, rasp leaf, and twisted leaf of cherry and ring spot of peach. In Ontario less important diseases are peach blotch, green ring mottle on sour cherry, yellow mosaic on sweet cherry, and line pattern mosaic on plum.

In British Columbia and Ontario there have been surveys to ascertain the distribution of these diseases, their symptoms, rate of spread, and the varieties affected; also host-range studies, and cross-inoculation studies. Indexing has been carried out to ascertain hosts giving characteristic reactions. Vector studies are under way. Preliminary thermal death-point and contact-period studies have been undertaken. Transmission, so far, has only been possible by budding and grafting. Control has been effected in some cases by roguing, in others by building up virus-free budwood for nursery propagation purposes.

Peach seedlings when budded outdoors in the fall react differentially to inoculations with prune dwarf, necrotic ring spot, and cherry yellows viruses, and therefore peach seedlings are of value in showing the presence or absence of these viruses. Peaches react to the necrotic ring spot virus by expressing delayed foliation and necrosis of shoots followed by recovery; they react to inoculations with prune dwarf by expression of rosetted shoots, with necrosis generally absent. With cherry yellows, however, peaches show the same shock symptoms as are associated with necrotic ring spot, and the same chronic symptom of rosetted shoots as is associated with prune dwarf. Peach seedlings are not satisfactory for indexing under greenhouse conditions as the rosetting of shoots is too mild to be of diagnostic value. There is another differential reaction of the peach that is of interest. If peach seedlings are cut back to the inserted buds in the spring following budding, the necrotic shock symptoms associated with necrotic ring spot or cherry yellows will be lacking. This is explained on the basis that the viruses do not become systemic in peach until after growth starts in the spring.

Several of the diseases dealt with induce symptoms early in the season and

then the host plants apparently recover. For instance, necrotic ring spot produces acute or shock symptoms of delayed foliation and necrosis on Montmorency cherry, peach, and Italian prune, followed by recovery of the trees. Moreover, symptoms rarely show after the first year. Cherry yellows virus produces a yellow leaf condition, with casting of leaves on Montmorency, three to four weeks after petal fall, followed by recovery. In this case, however, the yellows condition persists from year to year. On the other hand, the symptoms produced by the prune dwarf virus on Italian prune persist throughout the season and succeeding seasons. With several of the diseases the symptoms fade out during the hot weather of July and August, though they do not disappear entirely. This is true with line pattern on plum and peach and peach blotch on peach. Sweet cherry varieties may carry several viruses with little or no expression of symptoms; not all varieties react in the same way. After recovery from shock symptoms, Montmorency sour cherry may carry the necrotic ring spot virus without symptoms. Therefore, early in these investigations it was realized that ordinary nursery stock could not be relied on for experimental purposes. Accordingly, clonal virus-free stock is used for all experiment work. Such stock was found when indexing Montmorency cherry, Italian prune, Lombard plum, &c., on to peach seedlings. Peach seedlings are apparently healthy and react to these viruses with expression of characteristic symptoms. Thus when peach seedlings show no reaction from inoculation, the source tree is considered to be virus free.

Though many Montmorency trees have been observed which have shown only necrotic ring spot symptoms and inoculations from such trees have verified this diagnosis, every case of cherry yellows so far investigated appears to be contaminated with the necrotic ring spot virus. The true nature of the virus or viruses responsible for cherry yellows is not known at the present time.

In Ontario all trees affected by peach yellows, little peach, or the X-diseases are destroyed. It is recommended that every case of prune dwarf be removed, as such trees are worthless from a commercial standpoint. Cherry yellows and necrotic ring spot are so widespread that roguing is out of the question, and a supply of disease-free budwood is being propagated for the nurseries, to enable new orchards to set out with disease-free stock. No measures have been taken as yet to deal with the several other new virus diseases affecting stone fruits. In British Columbia the eradication of trees affected with little cherry became compulsory in the Okanagan district in 1947.

Dr. Berkeley used coloured lantern slides to demonstrate many of the diseases.

Mr. Robertson said that from what he had seen in America, Dr. Berkeley was putting the subject on a sound basis.

Dr. Harris (East Malling) asked if the diseases were due to single viruses or to virus complexes.

Dr. Berkeley said that some of the more important forms certainly seemed to be due to virus complexes, e.g. cherry yellows.

In reply to Mr. Bawden, Dr. Berkeley said that shock implied something more than just an initial symptom. Mr. Samuel thought that the term was a good one.

Dr. Berkeley was asked if there were reactions on the shoots and fruits. He replied that necrotic ring spot sometimes caused bark necrosis of peach and cherry but no definite symptoms were seen on fruits.

Professor Malcolm Wilson (Edinburgh University) asked how long stone fruit viruses had been in existence in Canada.

Dr. Berkeley replied that cherry yellows, previously called physiological

yellows, had certainly been in Ontario for many years and peach X for a number of years. Prune dwarf and some of the other viruses appear to be new.

Professor Malcolm Wilson suggested that intensity of cultivation was a factor in their origination.

Mr. Bawden added that the great increase in the transfer of plant material about the world was important. Peach yellows had apparently been present in U.S.A. for at least 200 years, but was now reduced in frequency.

Professor Baker wondered whether there was any spread of stone fruit viruses through natural transmission or whether it had been brought about by budding and grafting.

Dr. Berkeley said that most of the spread had been brought about by the latter method; there appeared to be some natural spread in the case of prune dwarf and it was low with X-disease.

Dr. Keyworth pointed out that single viruses often had no effect but that there was marked reaction when two viruses acted together.

Mr. Bawden added that speeding up of the spread occurred through new hosts and with the mixing of viruses.

Dr. Berkeley said that the actual number of viruses would probably be reduced when they had been put through their host range.

Dr. Prentice (East Malling) said that the disappearance of symptoms might be due to temperature relations as much as to advancing season.

Referring to the apparent increase in viruses Mr. Samuel said that many growers take no notice of virus diseases and send diseased material freely about the country; and Mr. Robertson indicated that half the wild plants in the Gold Coast appeared to have some sort of virus symptoms.

(*c*) 'The control of "Phloem Necrosis" of Tea in Ceylon.'

Dr. Bond (Sheffield University) said that since 1945 when he left Ceylon, work on phloem necrosis had virtually ceased largely as a result of the new need for work on blister blight (*Exobasidium vexans*) which was first recorded in the island in October, 1946. Phloem necrosis, though less spectacular, was, he thought, a grave potential menace to the crop, and should receive further attention when conditions at the Tea Research Institute permit. It was first reported towards the end of 1935 and was soon found to be widespread and probably also of long standing in a district which includes many of the highest tea estates in the Island, nearly all above 6,000 ft. At present, the disease may be said to occur almost everywhere above 4,000 ft., which means that it affects in all nearly a third of the total acreage under tea in Ceylon. From 4,000 to 5,000 ft., however, it is of little importance; but thereafter it becomes increasingly prevalent until at 6,000 ft. and upwards it may in some fields attain an incidence of 80 or 90 per cent., often in an acute form.

The symptoms of the disease are variable and much difficulty has been experienced in early diagnosis. Necrosis of the phloem can be seen in all parts of the plant, but especially in the roots. Affected bushes become progressively weaker, their productivity declines, and their average leaf-size diminishes. A dwarfing and distortion of the shoots occurs, involving a strong downward curling of the leaves and a zigzag alternation of the internodes. The evidence, so far, suggests that severe symptoms of this kind may not develop for perhaps the first year or more after infection under field conditions, though they may be hastened, for instance, during the period of recovery from pruning. Far more information is needed on the physiology of translocation in the tea bush before any adequate explanation can be offered of the vagaries in symptom expression that have been such a confusing feature of this disease. From the

field observations, with few exceptions, it is clear that in both incidence and severity the disease follows closely the distribution (with altitude) of the older and predominantly 'low *jat*' (small-leaved, less vigorous) plantings. Nevertheless, even in the most heavily affected fields, a small proportion of apparently healthy bushes does persist; and these bushes are commonly of more or less 'high *jat*' type. A start has been made in the propagation of clones by single-node cuttings from such bushes taking due account of their probable yielding capacity and other important characteristics.

The 'masking' of the symptoms of plant virus diseases at high temperatures is of relatively common occurrence, and may well be involved in the present instance. Nevertheless, experience of the disease in the field is borne out by the results of numerous graft transmission experiments in which only 'low *jat*' clones have reacted with typical symptoms. Among the 'high *jat*' material investigated, moreover, some plants at least have behaved as symptomless carriers, allowing the passage of the virus from one graft component to another without themselves showing any effects of its presence.

The only immediate control measure appears to be the systematic removal of non-productive bushes and their replacement by the best available 'high *jat*' seedlings, which so far have remained unaffected. In the older districts, the tea is of such mixed type and the proportion of bushes which are virtually out of production on account of phloem necrosis or other causes is often so high, that a roguing and replacement policy can scarcely fail to have beneficial results. In normal estate practice the roguing of diseased bushes is carried out only at pruning time and this means, in effect, only once every four or five (sometimes six) years. In certain experimental plots, systematic roguing every six months has reduced the potential rate of spread of the disease to about one-third of the value for comparable plots, left unrogued. This result is held to confirm the relative importance of 'bush-to-bush' spread, already predicted by statistical examination of all the available field plot records. Though of no immediate practical application, it may have an important bearing on the search for the insect vector, still undiscovered. There is no evidence for the mechanical transmission of the disease, as for instance by the pluckers working along the rows.

The virtually complete absence of phloem necrosis from the supplies planted out in the last fifteen years or so is most encouraging, but its continuance indefinitely cannot be relied upon. It may, for example, be only in part under genetic control, and for the rest merely an instance of what may be termed the 'van der Plank' effect—a disease-escaping capacity inherent in the smaller size of these young plants as compared with that of the old, necrotic bushes by which they are surrounded. One argument for the continued use of seedlings for tea propagation lies in the potential measure of diversity of this hybrid crop in relation to diseases and pests not yet encountered. As quality of tea alone is concerned, there is every advantage to be gained from the use of tested clones. However, it may yet be found that clones which are outstanding for quality are susceptible to phloem necrosis, or that those which are immune are of relatively poor quality, and it is in view of this possibility that there is, I think, an urgent need for further investigation of the 'van der Plank effect'. Close planting might do much to reduce the spread of phloem necrosis. If the plants are really small, roguing would be facilitated or the whole planting could be renewed, if necessary, at relatively short intervals. Vegetative propagation of tea by cuttings is now being adopted, and further innovations may yet be acceptable to the rather conservative growers. The present routine measures against phloem necrosis, successful though they may have appeared so far, probably do not provide the final answer to the problem.

(*d*) 'Tomato spotted wilt virus.'

Dr. Hopkins (Southern Rhodesia) dealt with control of tomato spotted wilt virus in Southern Rhodesia. He said that he would first describe the general economic and administrative conditions which governed the methods adopted in Southern Rhodesia, to control the distribution of what might yet prove to be a very serious disease of tobacco. This would form a background for the better understanding of the measures taken to suppress an outbreak of spotted wilt virus and prevent its introduction into tobacco-growing districts.

The Plant Pathology branch of the Department of Agriculture was staffed at the time by a woman assistant and himself. The duties were to maintain a plant disease advisory service for the Colony involving the usual laboratory diagnosis and more than 10,000 miles of travel by car a year; to investigate special diseases as they arose; and as far as possible to keep an overall watch on the diseases of crops, of which the most important was, and is, tobacco.

The value of the tobacco crop in Southern Rhodesia this year is likely to exceed £9,000,000, so that the possible introduction of a serious disease to this crop can only be regarded with grave concern. In 1940, when spotted wilt was first detected, the tobacco crop was smaller, but was still of great economic importance.

At that time the disease was known in South Africa as 'kromnek' in all host plants and its identity with tomato spotted wilt had not been established. Its known host range was therefore limited, as far as he was concerned, to those plants recorded in the Union. No staff was available for testing suspected host plants by transmission tests, so that diagnosis of the disease had to be based on circumstantial evidence.

He then gave some details of the epiphytotic which occurred in Bulawayo during 1940 and subsequent years when kromnek, introduced from the Union of South Africa in dahlias, spread from a collection of these plants in the Public Gardens to a wide range of other plants within a radius of about a quarter of a mile. Unfortunately, this included a nursery from which plants had been sold to the residents of Bulawayo and an inspection of twenty gardens belonging to purchasers of dahlia tubers or tins of seedlings (e.g. *Zinnia*) from this nursery showed that eighteen contained plants of various kinds infected by the virus. In no case had the disease been present before the introduction of plants from the nursery.

At the same time it was found that another commercial nursery had also distributed dahlia tubers containing the kromnek virus, but all the purchasers could not be traced and it soon became evident from reports received that the disease was widespread in Bulawayo; it was found in many gardens other than those previously inspected.

At that time no specific legislation existed for the control or eradication of kromnek. Nevertheless, the Department of Agriculture decided that an endeavour should be made to bring kromnek under control, and to this end a good deal of propaganda was put out. A little later a meeting of the local Horticultural Society, to which the general public was invited, was called and Dr. Hopkins pointed out the danger of the virus in dahlias in relation to the tobacco crop. He appealed to all growers of dahlias to uproot and destroy affected plants as a patriotic duty and added that possibly the ideal method to ensure complete eradication of kromnek was the destruction of all dahlias both healthy and diseased. Unexpectedly the public responded literally to this suggestion and most of the dahlias growing in Bulawayo were destroyed at once. In 1941 when a house-to-house inspection was organized kromnek was found in less than 3 per cent. of private gardens. Dr. Hopkins attributed

this largely to the removal of dahlias, because in subsequent years it has been his invariable experience that, where spotted wilt has been found on a variety of hosts, it has always been introduced in infected dahlia tubers.

From 1941 to 1943 frequent inspections were made of nurseries and gardens from which the disease had been reported but very few infected plants were found; these were destroyed. But despite ruthless destruction of all suspected kromnek in the Public Gardens the disease continued to appear on *Zinnia* seedlings used as test plants in the nursery. It was not until 1944 when young plants of *Brunfelsia*, showing mosaic mottling with distortion, and of *Pandanus*, showing uniform chlorotic spots almost identical with those caused by the punctures of scale insects (which were present), were suspected of being infected by spotted wilt virus and were destroyed, that the disease was finally eradicated from the Public Gardens. Numerous varieties of test seedlings were later raised in this nursery but no recurrence of kromnek was observed until early in 1947, when it was again found in dahlias obtained from a resident of Bulawayo. These plants were at once destroyed and no spread has occurred since. The garden supplying these tubers was inspected and the disease found in one variety, Jane Cowl, which had been grown continuously for many years in the same place. No spread had occurred.

On the other hand, kromnek was so persistent in the second nursery that it could not be eradicated by roguing year by year and it commenced to spread to other plants. The Government therefore decided in 1945 to buy up all dahlias in the nursery, which, together with a few other plants, were destroyed and there has been no recurrence of the disease.

It became evident that some unknown factors were deciding the natural spread of the disease, restricting it in some cases and favouring it in others, but one outstanding feature has been the invariable association of new outbreaks with the introduction of infected dahlia tubers. When, therefore, what were considered to be typical spotted wilt symptoms of ring and line patterns were observed in tubers imported from Holland, it was considered expedient to place a temporary embargo on such material until the authorities in Holland could issue certificates of freedom from spotted wilt based on field inspection.

Dr. McClean at Pretoria is assisting in the identification of dahlia viruses by inoculation trials and has stated that the typical South African kromnek in dahlias is caused by a virus lethal to the varieties of tobacco grown in Southern Rhodesia. Dr. Hopkins, therefore, considered that the action taken in Rhodesia was justified, but emphasized that further research into the local conditions governing the spread of spotted wilt was urgently required before any relaxation could reasonably be expected. The contradictory behaviour under apparently identical conditions could not at present be explained.

Dr. van der Plank (South Africa) pointed out the advantages of close planting as a method of reducing losses in tobacco and tomato crops by tomato spotted wilt virus. Around Pretoria when plants with four stems were grown widely spaced the crop of tomatoes was destroyed in two years out of three. When three to four single-stemmed plants were put in close together occasional plants only succumbed. Photographs used to illustrate this were handed round.

Mr. Samuel said that strains of tomatoes resistant to tomato spotted wilt in the United States had been sent to Australia, South Africa, and New Zealand; these had proved resistant in Australia but not in the other two countries. He suggested that there must be a real difference in strains.

Dr. van der Plank pointed out that tobacco grown under irrigation was, as a rule, more susceptible to spotted wilt than non-irrigated.

Mr. Bawden asked if there was any evidence other than the fact that they

are good feeding material for thrips for concentrating on dahlias when controlling spotted wilt.

Dr. Hopkins replied that dahlias were very popular and their distribution was a menace; they were frequently attacked and showed intensive symptoms.

Dr. Prentice (East Malling) wanted more information about close planting. He asked if smaller plants were more resistant to infection or whether the effect was just due to the fact that a 50 per cent. loss of plants in close planting was of less importance than a similar loss in ordinary planting.

Dr. van der Plank said that thrips do not breed on the tobacco leaves and consequently close planting was very effective. There was the same number of vectors for a larger number of plants as the vectors did not pass from plant to plant.

Mr. Pugsley (Waite Institute) mentioned the high percentage of tomato spotted wilt on potatoes in South Australia and the fact that the Pearl Harbor tomato is very susceptible.

Dr. Hopkins added a note on evidence of possible seed transmission of tomato spotted wilt in Tanganyika where one new variety showed mild kromnek.

Mrs. Watson (Rothamsted) said that in Australia a necrotic strain of spotted wilt virus from tomato killed tobacco leaves but did not spread. Norris thinks that it is the mild strains which multiply.

Meeting: Tuesday, 20th July, 2.30 p.m.

Chair: Mr. G. Samuel.

Discussion: **'The control of virus diseases (certification of vegetatively reproduced crops)'**

(*a*) Control of potato viruses by certification.

Dr. van der Plank (South Africa) dealt with climates which restrict the spread of potato viruses by *Myzus persicae*. This aphid, the chief vector of the potato viruses, overwinters on Brassicae or other hosts, migrates in spring or early summer to potato fields (directly or by devious routes), and multiplies there. Therefore, climates which restrict the spread of potato viruses by *M. persicae* can be classified in this way.

(1) Climates which restrict the overwintering of *M. persicae*; high latitude, continental climates with cold winters, e.g. Canadian seed-potato areas.

(2) Climates which restrict migration to potato fields. Cool moist climates which reduce flight:

  (*a*) Cool maritime climates, e.g. seed areas of the British Isles; ? Tasmania; ? New Zealand.

  (*b*) Moist mountain climates with free convectional movement of air, e.g. Inyanga (Southern Rhodesia), Northern Drakensberg (South Africa).

(3) Climates which restrict multiplication in the potato fields; very hot, dry climates, e.g. Kimberley area of South Africa.

(4) Climates which restrict the harm that the presence of aphids can do, e.g. those giving a low haulm-tuber ratio, short-day climates, cool climates, &c.

Dr. Gregory (Rothamsted) dealt with the spread of potato virus diseases in relation to seed certification. He pointed out that potatoes are grown in two distinct types of environment in relation to virus diseases: (1) seed-producing areas where, with a few simple precautions, a stock can be kept

indefinitely without becoming infected with the aphis-transmitted viruses, virus Y and leaf roll; (2) degeneration areas where a stock can be kept for only a few years before it becomes infected, has to be discarded, and a new stock brought in from a seed-producing area. Pioneer work on the spread of potato virus diseases in the field was carried out mainly in districts of the first type. In 1940 an ecological study of viruses and vectors was started in the lowland potato-growing areas of England, where rugose mosaic and leaf roll spread freely. The possibility was considered of growing high-quality seed in these areas by such methods as growing small isolated plots of stock seed potatoes, close spaced to get the maximum yield of seed; roguing to remove virus infectors; early lifting or burning of tops to forestall passage of the virus to the tubers; nicotine fumigation to destroy aphis populations; and rejection of stocks with high aphis populations. Dr. Gregory emphasized that the results obtained apply to an area not naturally favourable for potato seed production, and possibly quite different relations exist in naturally good seed-producing areas.

At first it was assumed that in summer winged *M. persicae* spread infection at random over a wide area and that the infected plants acted as foci for further spread in late summer by wingless aphids. Actually it was found that the number of *M. persicae* on a crop was poorly correlated with the spread of virus diseases; that much of the virus infection takes place unexpectedly early in the season; that most new infections occur within a few yards of the source and there is, as a rule, little spread of either rugose mosaic or leaf roll between fields.

There are several practical consequences of these facts. In a late variety of potato such as Majestic over half the rugose mosaic and leaf roll infections reach the tubers before the middle of August. This fact makes any control method which involves early lifting expensive, as the crop would have to be dug while the yield was still very small. Much of this early spread of rugose mosaic and leaf roll is local spread from infectors on the same field, brought about in June by the activities of winged immigrant *M. persicae* coming from other host plants such as Brassicas and sugar-beet seed crops. This fact reduces the value of nicotine fumigation, which provides excellent control of the aphis populations developing on potatoes, but its action is momentary. It is useless against the activities of the small numbers of highly active winged migrants which come into the fields, not as a rule themselves bringing infection, but which make short flights spreading rugose mosaic and leaf roll from infectors already present on the field. An insecticide is required which will not merely eliminate large populations of apterae, but will also prevent the feeding of winged immigrant *M. persicae*.

The winged immigrants also deposit nymphs which start the normal aphis infestation, often reaching a density of thousands per plant. However, the amount of virus transmission effected by the wingless progeny of the first spring immigrants is usually small. As an exception to this, in 1941 a large spread of leaf roll late in the season was noted. This was probably because the long intertwining stems of these particular crops facilitated the crawling of wingless aphids from plant to plant. Attempts to reduce plant size by close spacing have not been successful in reducing the spread of virus in experiments with potatoes, no doubt because wandering by crawlers is increased.

The relatively unimportant part played by crawling aphids explains why there is a poor correlation between field populations of any of the potato aphids and the amount of virus transmission. For this reason the inclusion of an aphis survey in the English Certification Scheme has not been recommended. Peak populations of many thousands of aphids per 100 leaves, or

per plant, may or may not be followed by extensive local spread of rugose mosaic or leaf roll.

The winged progeny of the wingless *M. persicae*, which are produced when the infestation is at its peak, normally fly to other hosts, and so they too play little part in spreading viruses among potatoes. Therefore the numbers of winged aphids trapped on a potato field in summer have also shown poor correlation with the spread of rugose mosaic or leaf roll.

All the evidence points to the few winged *M. persicae* which come into a field in late spring as the chief source of danger in the area investigated. This no doubt explains why, with few exceptions, the roguing of plants with second-year symptoms of rugose mosaic and leaf roll has proved useless in experiments at Rothamsted. The exceptions are only with rugose mosaic, and only then when it is possible to rogue as early as June. In this district a leaf roll infector planted with the stock may be expected to give rise to five or more new leaf roll infections in June, before the infector itself develops symptoms and can be rogued out. Roguing the infector-source will leave behind the new infections unrecognized. The virus content of the tubers from such a field would therefore be reduced from, say, 6 per cent. to 5 per cent. by roguing, an improvement which is not worth while.

However, roguing is worth while in districts such as the usual seed-growing areas, where a leaf roll infector gives rise on the average to one or fewer new virus infections before it can be spotted and rogued out. In less-favoured areas it is probable that the only effect of roguing is to help the farmer to get a certificate for an inferior stock by destroying the very evidence on which the inspector should refuse a certificate. In these areas roguing should be discouraged.

Although winged immigrants in June cause over half the new infections they do not necessarily bring the viruses with them. A mass influx of viruses into a field from outside has proved exceptional in our experience. They make many very short flights in various directions. The result is that the plant next in the row to an infector normally has a high probability of becoming infected. With leaf roll at Rothamsted the average probability is 50 per cent., but this falls rapidly to about 10 or 5 per cent. at five plants distance, and at a distance of over 25 plants we can normally raise seed worthy of a health certificate.

From the steepness of the infection gradient it can be deduced that (*a*) roguing could be improved by removing the two plants adjacent to an infector at the same time, and this practice might be recommended in areas transitional between natural seed-growing areas and areas where roguing is undesirable; (*b*) the usual isolation requirements in certification schemes are reasonably adequate; (*c*) the most important sources of virus infection are those already on the field, and therefore relatively easy to control. These sources can be analysed into two parts, infected tubers bought and paid for with the seed and volunteers. Any improvement in the health of seed coming from seed growing areas is immediately expressed as fewer infectors in lowland fields. Volunteers are unexpectedly common. In the course of a survey of fields under various rotations it was found that in the year following potatoes cereal crops normally contain 2,000 to 4,000 volunteer potato plants per acre (19,000 was the record), and that in an arable rotation the numbers were still high two or three years after potatoes, but only a hundred or two per acre after five years. Volunteer plants among cereals are not infested by aphids. Rugose mosaic or leaf roll do not normally spread among volunteer plants, and whether or not volunteer potatoes coming up in succeeding potato crops are a source of danger to the health of the seed depends on the health of the stock from which the volunteers are descended.

The general conclusion is that in lowland areas small yields of reasonably healthy seed could be produced by a combination of early lifting, roguing several times, and isolation, but that it would not be worth while so long as ample supplies of high-grade seed are available. Meanwhile by growing good stocks on land free from volunteers in reasonable isolation much could be done to prolong the life of a stock in an unfavourable area.

Mr. Samuel (United Kingdom) reviewed some recent developments in crop certification in England and Wales, referring to legislation making the planting of certified stocks of potatoes and the certification of strawberry runners and blackcurrant bushes offered for sale compulsory. He referred to the establishment of the high-grade Special Stock Certificate for strawberries derived from tested clones produced by the East Malling Research Station; to problems connected with the high-grade Stock Seed Certificate for potatoes; and to the recent extensions of schemes for the production of virus-free potatoes.

Dr. van der Plank said that there was confusion in the literature with regard to the spread of virus diseases. In Maine where the climate is dry the chief spread is from field to field. The cold winters allow no volunteer plants.

Dr. McKay (Eire) questioned the degree of tolerance of leaf roll which should be allowed in certification, since one per cent. in a stock grown in Dublin had given rise to 20 per cent. in the crop. He suggested that roguing may shake aphids off the diseased plant and spread them to others, and therefore there was more infection after roguing than in an unrogued crop.

Dr. Gregory agreed that it was more dangerous to rogue in south-east England but that the situation was different in Scotland. If no roguing is done how are the viruses to be eliminated? He would like to see a stock so improved that there was no leaf roll.

Mr. Samuel said that the aphid population in Maine was enormous. Application of D.D.T. had reduced the numbers considerably and yet there was more leaf roll. He believed that the aphids were either spread by the machine or stimulated to move by the fungicide.

Mr. Bawden (Rothamsted) maintained that there were fallacies underlying van der Plank's hypothesis. Sometimes there was little aphis and yet a staggering amount of leaf roll. The lack of correlation is so great that if stocks were certified on the aphid population many would be certified when they had a high virus percentage. At Rothamsted there is a low top–tuber ratio and much spread whereas in Lincolnshire where tops are big there is little spread. Movement of aphids appeared to him to be important. Static insects were not virus infectors, but anything causing even a small number of aphids to move was also increasing the viruses. The factors which make potatoes susceptible are also important.

Mr. Samuel thought that the field work should be left now and the aphids themselves studied in more detail.

Dr. Broadbent said that aphids fly the same amount in both moist and dry climates. A change of humidity may alter the flight period temporarily but after acclimatization it becomes the same. The low populations under conditions of high humidity may be due to the low build-up on the plant. High humidity plus high temperature (30° C.) also restricts them. The spread all appears to be due to the winged aphids and none to the wingless.

Dr. McKay declared that to get virus-free stocks either the aphis or the infected plant must be eliminated. They had virus-free stocks in Ireland but even so leaf roll had increased due to aphids and the importation of infected stock. Leaf roll plants should be eliminated and for first-class certificates should not be allowed.

Mr. Bawden pointed out that sometimes leaf roll spreads more quickly

than rugose mosaic and sometimes the other way round although they have the same vector. The explanation appeared to lie in the activity of the aphids.

Dr. Broadbent suggested that as the aphids need a long feed to pick up or transmit leaf roll virus, if the day were unsuitable for flight leaf roll was more likely to be spread and if favourable then rugose mosaic would be disseminated.

Mr. Conners (Canada) said that while it is possible to reduce mosaic to a uniform low level, leaf roll was very variable and would suddenly increase. He asked if any work had been done in this connexion on the natural hosts.

Dr. Gregory replied that very little had been done in the case of leaf roll, but one could not exclude the possible danger of perennial and overwintering reservoirs of the virus. He had tested *Solanum dulcamara*, *Rhamnus*, and peach. However, there would be greater 'edge' effects if the virus were coming from wild hosts. More appears to come in from other potato fields but most spread occurs in the same field.

Dr. Keyworth (East Malling) asked if the gradient of infection were a distance effect or dependent on the number of potato plants in between. If the food plant is near and plentiful the insect will not fly, but it would be interesting to know what would happen if the plants were isolated.

Dr. Gregory replied that it was a distance effect, the best barrier to spread probably being ground covered with potatoes.

Mr. Bawden in reply to a question from Dr. Keyworth said that isolated plants were more effective as infectors and that it was the number of plants and not the distance that mattered. Isolated plants in another crop were not dangerous provided the crop was not potatoes or Brassicas.

Dr. Whitehead (Bangor) maintained that we have insufficient facts to go on. Those accumulated in an area of bad leaf roll cannot be applied to a 'seed'-producing area. There was no doubt that correlation exists in 'seed'-growing areas between the numbers of *M. persicae* and virus spread, and that spread is determined by the number of foci of infection.

(*b*) 'Virus disease problems in the certification of fruit and hops.'

Dr. Harris (East Malling) dealt with research on the virus diseases of soft fruits and hops particularly relevant to the certification of planting stocks for health and productivity. Certification of these crops in its simplest form is based on maintaining a high standard of freedom from visual symptoms, determined by one or two annual field inspections. Dr. Harris explained the terms virus expression, sensitivity, tolerance, and klendusity.

Discontinuous symptom expression, or symptom masking, with its obvious direct bearing on the validity and timing of annual field inspections, has been found to be a feature of strawberry yellow-edge (affecting both so-called sensitive and tolerant varieties); mosaic 1 of raspberries (a relatively mild disease); Scottish leaf curl of raspberries (of the utmost importance here); and nettlehead of hops. The irregular seasonal and positional expression of nettlehead constitutes a major problem in hop certification and is only one of the problematic features of this disease, research on which is yet in its initial stages.

Through recent analysis of strawberry yellow-edge and severe crinkle by combined grafting and differential aphid-vector transmissions, these major diseases are now known to be virologically composite and inter-related and the simpler diseases, such as mild crinkle, although comparatively innocuous in themselves, thus assume importance in certification as components of the severe or major diseases. The analysis of raspberry mosaic and other virus diseases is producing a broadly similar picture. This work is not yet so

advanced, largely owing to the greater complexity of the viruses and to factors (as yet imperfectly understood) militating against successful artificial aphid-vector transmission, factors presumably causally related to the high klendusity of this crop to the mosaic diseases. But by grafting transmissions to a series of raspberry varieties and other *Rubus* species as differential indicators, it is now concluded that the severe raspberry mosaic diseases are likewise composite and inter-related.

In varietal expression and sensitivity lies the crux of the certification problem, the relation between diagnostic symptoms and virus content. With black currant reversion (apparently a simple virus disease) no problem arises as all varieties are both highly sensitive and expressive. An adequate standard of certification can therefore be maintained simply on the basis of field inspections. Certain hop varieties are true carriers of mosaic, including the widely grown Fuggle and the new Wye seedlings. Regional segregation of the sensitive or Golding varieties from these tolerants is practised, and attention is also being given to producing clones of virus-free and expressive male hops. No evidence of carrier varieties of nettlehead has yet been found.

With strawberries and raspberries the problem of interpreting symptoms or their absence has a complexity corresponding to the complex etiology of the major diseases already noted. Varieties of both crops fall into two well-defined groups for certification purposes, the so-called sensitives and tolerants. With strawberries this distinction refers solely to one combination of viruses producing severe yellow-edge, and high sensitivity is here accompanied by high expression and vice versa. But we know that there is at least one other etiologically distinct form of severe yellow-edge to which the tolerants (or Huxley group) react both sensitively and expressively (this refers to the so-called 'breakdown' of tolerants), although still not so expressively as the corresponding sensitive or Royal Sovereign group of varieties, so that successful roguing is still problematic. Finally, all varieties of the cultivated strawberry, even the sensitives, fail to express infection by the single virus components of the major diseases adequately for field-inspection purposes, and other methods for assessing such infection must therefore be applied.

Raspberries may similarly be segregated into the sensitive or Norfolk Giant class and the tolerant or Lloyd George class, but again the distinction is limited and needs careful qualification. Unlike strawberries, the sensitive raspberry varieties show high expression not only of the major diseases (mosaic and Scottish leaf curl) but of some at least of their individual virus components. This high degree of expression (and sensitivity) is also associated with high klendusity, and such varieties can therefore be efficiently and easily certified on the basis of field-inspection alone. Unfortunately, commercial varieties of this type are exceedingly rare at the present time; the majority of good varieties belong to the tolerant or Lloyd George group. Both the expression and the tolerance of these varieties is very limited. The majority of the important raspberry virus elements (singly and in association) are either non-expressed by this class of variety or produce symptoms inadequate for field-inspection purposes. These varieties are highly tolerant of certain of these non-expressed viruses, but the addition of other, and as yet unidentified, viruses at this tolerated level induces a steady decline or degeneration of the stock but (unlike strawberry 'breakdown') without the expression of diagnostic symptoms.

Stocks of both the sensitive and tolerant strawberry and the tolerant raspberry varieties may become infected with components of the severe or major diseases, or in the case of raspberries, with the major diseases themselves without symptom expression adequate for critical and effec-

tive field inspection and elimination purposes. The conclusion is that the certification of strawberries and of the most important raspberry varieties must incorporate a standard of freedom from virus diseases (or of health) more comprehensive than that afforded by visual field symptoms alone. That means it must be based on pedigree or 'nuclear stocks' tested directly for virus freedom by grafting to indicator varieties or species. This is the reason for the Special Stock Scheme for strawberries now in operation in this country, but this scheme is still in its adolescence. It is not enough simply to launch a virus-free tested stock *ab initio*, for that stock will not maintain its virus-free status on the basis of field inspection alone, whatever precautions of isolation and vector control are applied. Provision must be made for regular replacements of the stocks under bulk-propagation by the grower-propagators from the tested or nuclear sources. This implies an organization with facilities for the production and maintenance of continuous supplies of tested virus-free stock of each variety under certification. The minimum condition of certification under such a scheme would be broadly as follows: (*a*) adequate isolation of nursery beds from virus sources (including insect vector control), (*b*) adequate cultural conditions, (*c*) periodic inspection and roguing on visual symptoms (as for existing schemes), (*d*) regular and frequent replacement of stock by beds planted with fresh supplies of nuclear stock. Such a system has been worked on an experimental scale with Lloyd George raspberry, and the provision for continuous replacements of nuclear stock appears to be much more practicable than the alternative, namely, the putting out of an initial supply of nuclear stock indefinitely with irregular withdrawals and replacements on the basis of visible degeneration or on estimates of virus infiltration by large-scale random-sample tests.

Mr. Samuel said that a central station was being established for multiplying virus-free stocks.

Meeting: Thursday, 22nd July, 10 a.m.

Chair: Dr. van der Plank.

Discussion: **'The diagnosis of nutritional disorders.'**

Dr. Roach opened the subject by mentioning the main types of methods in use for the diagnosis of mineral deficiencies. He emphasized their limitations, but said that in spite of these their use has already led to considerable increases in yield and improvement in quality of crops, adding that great possibilities were indicated for the future.

The study of mineral deficiency has been rendered much more complicated and difficult by the discovery, during the last decades, that many elements are essential for plant growth, especially those required in very small amounts, e.g., sulphur, iron, and manganese (0·1 per cent.); zinc, boron, and copper (0·01 per cent.), and others seem likely to be added to the list. Vanadium and molybdenum (about 0·000005 per cent.) are known to be essential to certain plants, and spraying plants with nickel has been proved to bring about economically important increases in yield in three crops. Dr. Roach dealt mainly with these trace elements or micro-nutrients.

Soil analysis has been of little use for the diagnosis of trace-element deficiencies, but two simple tests have been found useful. The Comber test for soil acidity can also be used as a rough test for the degree of availability of the iron and other trace elements, such as manganese, zinc, and boron. No evidence of any serious trace-element deficiency has been found in soils

giving a definite pink or darker colour with a saturated alcoholic solution of ammonium thiocyanate; but absence of colour is only indicative of trace-element deficiency in the absence of much organic matter. The other test consists in pouring acid gently over the soil. In fertile soils effervescence is usually localized around isolated particles of calcium carbonate; when a soil froths like beer, indicating that it is completely permeated by calcium carbonate, then trace-element deficiency is almost certain.

Field fertilizer trials are of little value because the so-called 'trace-element deficiency' is more commonly a lack of availability than an absolute shortage of the element, and application of trace elements to the soil are more often than not rendered ineffective by soil fixation, especially in alkaline soils. Trials have been made in green-house and laboratory using a small plant or fungus in place of the usual crop plants. The utility of these biological methods is limited because species of plants, and even varieties of the same species, differ markedly in their ability to abstract nutrients from the same soil.

Leaf analysis may be applied to the growing crop to find out how far its nutrition is adequate in time for curative treatment to be effective on the same crop. The determination of many elements in minute amount in the presence of comparatively very large amounts of seriously disturbing elements such as silicon, calcium, and phosphorus is a difficult matter; and the methods employed (spectrographic, polarographic, and chemical) leave much to be desired. But in experienced hands, leaf analysis is giving valuable indications. The safest procedure is to compare extremely unsatisfactory plants with a range of the more satisfactory ones that can usually be found growing near by, and with comparable really satisfactory plants from elsewhere. The interpretation of the results of such analyses is not always straightforward, for example, abnormally large contents of either calcium or phosphorus tend to interfere with the utilization of trace elements such as iron, boron, and zinc, and even though normal or large amounts of these elements may be present their adequacy must be tested by other methods.

A method of diagnosis, developed largely by Wallace, is based on the fact that nutrient-deficient plants often exhibit striking leaf and other visual symptoms. Plants are grown in sand or water culture under known nutrient-deficient conditions and their symptoms studied in the hope that when similar symptoms are seen in the field they will be due to the same deficiency. This method has given valuable results, e.g., the diagnosis of widespread potassium deficiency in fruit-trees by the marginal leaf scorch and associated symptoms. Practically identical marginal leaf-scorch symptoms may, however, be produced by injecting an excess of any of a number of the major element nutrients, e.g. the sulphates, chlorides, and nitrates of ammonium, sodium, and also potassium. In so-called leaf-injection methods use is made of the fact that if a cut made in a plant is kept moist with an aqueous solution, the liquid is usually sucked into the plant and travels along definite routes and its distribution in the plant can be predicted. Thus, by making the cuts in suitable places, parts varying in size from a single interveinal area, or the half of a leaf on one side of a midrib, to a main branch of a tree, can be permeated, and similar neighbouring parts can be left untreated for comparison. Leaf-injection methods provide means for testing the effects of nutrients, each on a separate interveinal area or half-leaf, on leaf colour, and growth; a preliminary indication can sometimes be obtained in a few days and usually within a fortnight or three weeks. It cannot always be assumed that a nutrient that brings about an improvement in leaf growth or colour, or both, will necessarily increase the crop or improve its quality.

Each of the types of method mentioned is only preliminary; final diagnosis

is based on increase in yield or improvement in quality of crop resulting from treatment.

Branch injection provides one method of final diagnosis. Each branch of a tree (particularly a spur-pruned fruit-tree) may be injected with nutrient without affecting the rest of the tree; and the effects on yield and quality of fruit can be studied. This method of whole tree injection was used by Atkinson (1935) in New Zealand, McLarty (1936) and Young and Bailey (1936) in Canada, and Jamalainen (1936) in Finland to prove that corky core of apples is the result of boron deficiency. This led to a commercial cure of probably the most serious deficiency disease of the apple. The method was also used in this country to diagnose manganese deficiency in cherries, and treatment led to heavy crops being produced by some thousands of previously barren or poorly productive trees, many of which were at the point of death.

It is one thing to deal with such extreme deficiencies, mainly of a single element, but quite another to deal with a deficiency responsible for, say, a 20 per cent. loss of yield; and the difficulties are greatly increased if there are a number of deficiencies, especially if there are strong interactions between their effects. Then complex factorial experiments are essential for reasonably rapid progress and the proper choice of plot size becomes of paramount importance. The development by Barclay of what may be called a micro-plot method has opened up great possibilities in this direction. His experiments were carried out in commercial fields without any interference with normal cultural operations, all of which were done by the farmer concerned. Yields of each field as a whole, estimated from that of the experimental plots, corresponded closely with the actual yields—a fact that bred confidence in the farmers concerned.

Details were given of results obtained during the war, mainly on the alkaline silt soils of the Romney Marshes in Kent. These pastures when ploughed grew poor arable crops. The crops varied from practically nothing on the lowest parts of a field to a poor crop over most of its area, but on small areas raised often only a foot or so above the general level the crop was often excellent. Over the area as a whole symptoms of manganese deficiency were widespread. Spraying experiments proved manganese deficiency to be of major economic importance, some of the increases in yield per acre being: 17 cwt. wheat, 14 cwt. barley, 11 cwt. peas, 4½ tons parsnips, and 2 tons potatoes. Some of the largest of these increases were obtained on crops that looked perfectly healthy, and there was little to suggest that greater increases were obtained on the poorer than on the better healthy-looking areas of the fields.

Details were also given of results obtained with mangolds grown on an alkaline peat at Malling. From an early stage these showed symptoms of manganese deficiency; the increase from spraying was slight where the symptoms were severe but large where the symptoms were so slight as to be hardly noticeable. Dr. Roach said that the heaviest crop of mangolds he had ever seen (about 70 tons per acre) had, throughout their life, the most severe symptoms of manganese deficiency that he had ever come across.

Large as were the yield increases obtained by spraying with manganese, they were not large enough to turn the negligible crops into bumper crops. Leaf injection experiments on a number of crops gave responses to all the trace elements tried, not only manganese but iron, zinc, boron, copper, and nickel. Barclay proved by his complex experiments that each of the elements brought about yield increases of real economic importance when sprayed. In 1945 a 7 ton per acre crop of potatoes, showing extremely severe symptoms of manganese deficiency, when sprayed with manganese showed a really spectacular improvement in leaf colour, but *no* increase in yield. Zinc alone

had no noticeable effect on foliage but probably brought about a slight increase in crop amounting to 26 cwt. per acre, but spraying with both manganese and zinc led to an increase of 4 tons per acre. In 1946, however, in another field a crop of 14 tons per acre was increased to $17\frac{3}{4}$ by manganese alone, to $16\frac{1}{2}$ by zinc alone, and to $19\frac{1}{2}$ by manganese and zinc together. Very large crop increases and yields were obtained although nowhere near the ideal mixture of trace elements was evolved. The results hold out the hope of still larger increases when this is done. There was good evidence too that the number of tubers rotted by blight [*Phytophthora infestans*] was reduced by the foliage spray of manganese and zinc at concentrations much too low to have any direct fungicidal effect.

Dr. Roach concluded by saying that he believed that there are really great possibilities of crop increases by curing trace element deficiencies, not only in crops that look sick, but probably, even greater in the aggregate, in crops that show no obvious visual signs of deficiency.

Dr. Nicholas (Long Ashton) dealt with chemical tissue-tests for the determination of the mineral status of plants. He said that the practice of determining the mineral requirements of plants by means of chemical tissue-tests originated in America. These procedures include qualitative staining, expression of the sap, extraction of nutrients using a variety of solvents, and the use of a Waring blender for the determination of 'total soluble' nutrients in plant tissues.

A tissue-test technique has been developed at Long Ashton to test quantitatively a number of the easily soluble nutrients in fresh plant tissues within a short time. Its value as a diagnostic method is based on the fact that the extractable nutrients from healthy as compared with plants deficient in a mineral element usually show significant differences for the limiting nutrient. Toxicity levels of nutrients can also be detected by comparison with extracts of healthy plants. In this way deficiencies of K, Mg, Ca, P, N, and Mn, and excess levels of Cl, Mn, Al, Zn, Cu, Pb, Co, Ni, and Cr can be readily confirmed within a short time.

The method involves a special field sampling technique and preparation of test samples, followed by the extraction of the nutrients from the finely chopped tissues. Three reagents used for extraction are: (1) glacial acetic acid buffered by means of sodium acetate at pH 4·8, for extraction of K, Mg, P, nitrate N, Cl, Mn, and Al, the last two when present in excess (this reagent is specially purified for the detection of Mn at normal and deficient levels); (2) 100 gm. of sodium acetate dissolved in N. HCl, used for the extraction of Ca from cereals and root-crops as reagent (1) does not extract a sufficient amount late in the season; (3) hydrochloric acid used in special instances for the extraction of Fe, Zn, Cu, Co, Ni, Cr, and Pb.

The assessment of turbidity or colour is made using prepared standards calibrated by means of the Spekker Absorptiometer or comparator and discs, and these are grouped into high, medium, and low values and a further subdivision is possible using plus and minus signs. These values vary with nutrient and crop plant and a working knowledge of them is essential for diagnostic work. Threshold values have been determined for the various nutrients and these usually coincide with the onset of visual signs of the particular deficiency or toxicity. In many instances tissue test values give a clue to an impending mineral deficiency or toxicity prior to the onset of visual symptoms.

A critical study has been made of the effect of the seasonal cycle on the extractable nutrients in a variety of vegetable and fruit crops growing on long term manurial trials, in order to determine, at various points in the growth cycle, a mineral deficiency effect as distinct from a seasonal trend.

Tissue-test results usually reflect the nutrient treatment and also show crop differences for the same treatment. The agreement with the visual diagnosis method is close and thus it is a valuable adjunct to the study of symptoms in the field. The correlation between tissue-test and full chemical analysis data is usually close and the method may be used to replace the longer and more tedious procedures of ash analysis in the diagnosis of mineral deficiencies and toxicities.

The following complex nutrient disorders, viz., the acidity complex comprising Ca deficiency and Mn and Al toxicities in vegetable crops, K and Mg deficiency in fruit-trees, K deficiency and Cl toxicity in red currant, Zn toxicity and related Fe deficiency in crop plants, have been elucidated using the tissue-test method.

Dr. Nicholas showed a field testing outfit with the results of some of the tests.

Dr. Hopkins (Southern Rhodesia) asked what benefit would result from treating soils in fruit-growing districts in Southern Rhodesia which were deficient in calcium, potassium, and phosphorus.

Dr. Roach said this could be proved only by trial, but warned against overliming. In South Africa where excess lime had been used many trees, especially peach, had been killed. In England poor potato crops on acid soils had benefited from small dressings of lime but had shown trace-element deficiency where heavy dressings had been applied.

Dr. Hopkins related how, in Southern Rhodesia, fruit-trees sprayed with zinc and boron compounds for two years had made much fresh growth and flowered uniformly. Two years after cessation of treatment all new growth had died back and the trees were in worse condition than before.

Dr. Wiltshire (C.M.I.) said that materials had been sent to this country for spectroscopic analysis in connexion with various obscure diseases in the Commonwealth (e.g., clove disease in Zanzibar and the unknown disease of coco-nut in the West Indies). This method gave no indication of the threshold values which might be quite different in the tropics. He asked if Dr. Nicholas's method would be workable by any ordinary pathologist.

Dr. Nicholas said that the clove leaves which had been analysed at Long Ashton showed that abnormally high manganese content was linked with low calcium. This was confirmed later by soil analysis. Nutrient correction with addition of lime had been recommended. He thought a pathologist with some chemical training could use the tissue diagnosis technique, but added that the determination of threshold levels would be a full-time job for a chemist.

Mr. Robertson (W.A.C.R.I.) said that there were physical difficulties in testing cacao and citrus leaves in the field and suggested that a visit by an expert would be of value.

Mr. Samuel asked if any practical use was being made of the new techniques in this country with a view to detecting incipient deficiencies. In Australia the problem was more acute—how were the Australians dealing with this practical application?

Dr. Roach replied that some advantage had been taken of the method in Britain. A large area of cherries had been treated for deficiency by the injection technique and this was followed by routine spraying. On three large farms on Romney Marsh routine spraying of potatoes had been adopted.

Mr. Samuel asked if trace elements were added to blight-sprays.

Dr. Roach said that he was not sure.

Dr. Nicholas said that advisory chemists are equipped with tissue-testing outfits which enable them to diagnose deficiencies speedily and thus correct them early in the season. Many sets had been sent to the colonies.

Miss Eardley (Waite Institute) said that the opening up of new lands in

Australia was aided by mineral deficiency work. The type of deficiency likely to occur on certain lands was known and advice given accordingly. Manuring with small amounts of manganese has been found to improve pastoral properties in certain areas. In many places it is a standard practice to add superphosphate, and such manures can now be bought with added manganese at a slightly increased cost. Zinc deficiency is a problem in poor lands given over to commercial forestry in Western Australia and some eastern states. Responses had been obtained by spraying and injecting.

Discussion: 'Losses due to fungi in stored foodstuffs.'

Mr. Snow (Reading University) in introducing the subject said that it was still most important to prevent wastage of cereals and other foodstuffs in storage or transit. The Food and Agricultural Organization have estimated that in comparison with a loss of 5 per cent. of the world's cereals, pulses, and oil-seeds due to insect damage and 4 per cent. due to rodents, 1 per cent. is due to mould fungi. Heating, which also results in losses, is frequently attributable to the activity of mould fungi. Oxley and Jones have suggested that the presence of mould mycelium beneath the epidermis of the grain may account for increased respiration and heating of wheat. Milner *et al.* have isolated *Alternaria* spp. from the inner surface of the wheat pericarp although they consider that it is the activity of surface contaminants, such as *Aspergillus* spp. and *Penicillium* spp., that cause most of the heating.

Mould damage in stored products can usually be related to either a high moisture content of the material stored or to a high atmospheric humidity of the place of storage. Galloway showed that, for textiles, the rate of mould development was better related to the relative humidity of the storage atmosphere than to the moisture content of the substrate. The same was found to hold true for feeding-stuffs stored at controlled humidities and moisture contents. Extensive moulding occurs within about four weeks on most cereals and other feeding-stuffs stored at humidities between 100 and 75 per cent. Below 75 per cent. mould development is not prevented but a much longer latent period is required before spore germination can occur. Thus moulding has been shown to take place on certain feeding-stuffs stored at humidities as low as 70 to 65 per cent. after periods of one to two years.

As a result of observations on feeding-stuffs stored at controlled humidities it has been possible to state that a humidity of 72 per cent. is safe for short-period storage (up to 3 months) but that 65 per cent. must be accepted as the safe maximum for long-period storage (up to three years). For bulk storage of various foodstuffs it is possible to calculate the moisture contents that are in equilibrium with these safe levels of atmospheric humidity. The safe moisture contents for short-period storage range from 9·5 per cent. moisture for bone meal to 15·7 for wheat, 14 for legumes, and 12 for oil-cakes. The corresponding figures for long-period storage are about 1 per cent. lower.

It has been shown that at high relative humidities (100 to 90 per cent.) a wide range of species can be isolated including members of the Mucorales. *Penicillium* spp. are able to flourish between 100 and 85 but are not usually isolated below 75 per cent. *Aspergillus* spp., however, are able to grow under conditions of very restricted moisture supply. Species of the *A. glaucus* group, particularly, are able to grow at humidities often as low as 70 to 65 per cent. The members of this group with small ascospores, e.g. *A. repens* and *A. ruber*, are most frequently isolated from foodstuffs stored at sub-saturated atmospheres.

It is evident that each species has a range of humidity over which spore germination can take place. For some species, e.g., *Mucor* spp. and *Botrytis cinerea*, this range is very restricted (100 to 93 per cent.). Different species of *Penicillium* have critical humidities of between 86 and 80. *A. niger* has a critical humidity of 84, while spores of *A. sydowi* do not germinate below 78 per cent. Species of the *A. glaucus* group are the least exacting in their moisture requirements for spore germination. *A. repens*, *A. ruber*, and *A. echinulatus*, in particular, have all been isolated from feeding-stuffs stored at humidities as low as 70 to 65 per cent. Spore germination tests at controlled humidities have shown that these moulds are able to produce active germ-tubes under conditions of such restricted moisture supply provided that a sufficiently long latent period is given.

In control it is essential, firstly, to identify the species of mould which is causing damage and, secondly, either to reduce the humidity of the place of storage to a safe level at which spore germination cannot occur or to reduce the moisture content of foods stored in bulk. Under certain circumstances it may be possible to use some antiseptic to prevent mould growth. Unfortunately the really effective mould deterrents are usually poisonous. Of the less toxic compounds borax or boric acid, benzoic acid, and the sulphur drugs (sulphanilamide, &c.) have been suggested. It seems unlikely, however, that these will have very general application.

Much taxonomic work remains to be done on the proper identification and classification of the micro-fungi found on stored foods. Furthermore, the reasons why some species are able to withstand much wider ranges of humidity than others require more detailed elucidation. The chemical changes that result in stored foods following mould action also offer a large field of study which has a bearing on the palatability and digestibility of various foodstuffs both for human and animal consumption.

Dr. L. E. Campbell (British Food Manufacturing Industries Research Association) contributed a paper on the 'Losses due to fungi in stored cocoa', which was read at the meeting by Mr. Owen.

There are two groups of moulds on cocoa-beans, those occurring inside the bean and those which grow on the surface of the shell. The latter are unimportant in that they cannot penetrate the dry, intact shell. One of the main objections to germinated beans is that the piercing of the testa opens the way for mould invasion. Insect attack probably assists the entry of moulds in this way and may possibly bring in mould spores. Moulds can penetrate the dry shell only through a crack or other aperture. If sufficient moisture is present, growth can take place; normally no mould attack occurs if the moisture content of the beans is less than 8 per cent. Whilst in the tropics exposure of the beans to relative humidities over 82 per cent. will cause mould, in England it does not, probably because the air temperature is much lower, and the actual percentage of moisture in the air is less.

A number of genera attack cocoa-beans, the more common being *Aspergillus*, often giving black colours, '*Oidium*', producing white mycelium, and *Penicillium*, which may be green or yellowish. The extent of mould attack varies from a very few hyphae just visible with a hand lens between the folds of the cotyledons, through obvious discolorations in these folds, to extreme cases where the whole interior of the beans is a powdery mass of the fungus. Different kinds of mould produce different types and amounts of flavour, even with the same degree of infection. Flavours are undetectable with the very light attacks visible only with a lens; very strong offensive flavours depend on the kind of mould. Usually moulds produce musty types of flavour. As cocoa-butter is a stable fat, ketone rancidity is not caused, and peroxide

rancidity is not usual owing to the presence of cocoa antioxidants. Lipase of moulds does, however, give rise to the liberation of free fatty acid. The musty flavour produced by mould may render the cocoa-beans useless for the manufacture of chocolate or cocoa-powder; it cannot be removed from the nibs. However, the nib can be used for cocoa-butter and also for theobromine. The cocoa-butter has to be treated with alkali to remove the fatty acid liberated by the lipase in the moulds and the yield is, therefore, lower than it would otherwise be. Appreciable mould attack can cause bigger losses of cocoa-beans from both the chocolate and fat-expressing aspects than any other defect.

If stored beans are wetted they must be dried at once, or at most within a day or two depending on the temperature, since the many moulds dormant on the shell will quickly develop, and penetrate the moist shell. Once the mould is growing inside the bean, it is extremely difficult to stop growth simply by drying. If cacao has been dried in the tropics and is not wetted by sea water or sweat-damaged during transit, there is little danger of mould development in stores in England. The wetting of stored beans causes the remnant of mucilage adhering to the shell to become sticky. Subsequently, these wetted beans can be detected by their clumping together in the bags instead of being free as are dry beans.

Dr. C. F. Sharman (Imperial Tobacco Company Ltd.) contributed a paper on 'The significance of mould growth in the tobacco industry', which was read at the meeting by Dr. Wiltshire.

As tobacco is a highly nutritious medium it is vulnerable at all stages to fungal attack. The importance of this attack, however, from the commercial point of view varies greatly at different stages owing to large variations in moisture condition. During the curing process, whether by flue-curing, air-curing, or fire-curing, probably most of the parasitic moulds even of the facultative group are killed; but in the curing-barns and during marketing and re-ordering a fresh saprophytic flora settles on the leaf. The curing process and subsequent handling involve large fluctuations of moisture content and during favourable periods the spores are able to develop and ultimately produce various types of damage in the cured leaf which are known by the names of 'Pole sweat', 'Stem rot', 'Fat stem', 'Black rot', &c. The reduction of this damage to a minimum calls for great skill in atmospheric control on the part of the farmer. Mould growth during curing is likely to be a stumbling block of the amateur tobacco producer in this country at the present time. Commercial leaf is finished in the moisture range of 10 to 14 per cent., and in this state is safe from attack by fungi.

After shipment to this country the leaf is normally stored in bonded warehouses in compact masses varying in weight between 100 and 1,000 lb. for a period up to three years. In the best practice some uptake of moisture occurs on the outside layers, but this is not sufficient to permit the development of fungi. It is safe to say that any damage by mould in bond can be counted as accidental.

On entry into tobacco factories the first process is always one of moistening. In cigarette manufacture, the tobacco at no stage attains a moisture content sufficiently high to support mould growth, and the preparation of pipe tobacco in general is too rapid for appreciable mould growth to make its appearance before leaving the factory. An exception to this is roll tobacco where the process of manufacture is prolonged for several weeks and great care is necessary to prevent serious trouble. A tobacco manufacturer is prohibited by law from using any fungicide other than acetic acid. The disadvantages of this are its volatility, corrosiveness, and rather poor preservative quality.

The product then passes out of the control of the manufacturer and this is the stage at which mould growth becomes significant commercially. Cigarettes normally present little difficulty since their moisture content is low; hence if they are wrapped in one of the modern moisture-proof materials (at the moment this material is severely rationed), they are capable of surviving storage for many weeks under the varied atmospheric conditions encountered in retail shops. Pipe tobaccos in non-airtight packings present a more difficult problem. The moisture content has to be carefully adjusted so that when the tobacco is purchased it has not become unsmokable on account of dryness, yet is sufficiently dry to prevent the development of moulds. The factors involved in making the adjustment are the type of tobacco, original moisture, efficiency of moisture-proof packing, acetic acid content, average shelf-life of brand, and the average temperature and humidity of storage.

The types of fungi found on packed tobacco include most of the cosmopolitan forms, and those which nearly always occur are species of *Aspergillus*, *Mucor*, *Monilia*, *Penicillium*, *Fusarium*, and *Alternaria*.

Mr. Dade said that during the fermentation of cocoa-beans fungi penetrate through the micropyle as well as through cracks.

Mr. Snow in reply to Dr. van der Plank said that most of his work had been done at 25° C. Storage is probably safer at a lower temperature.

Dr. Tomkins (Low-Temperature Research Station, Cambridge) stressed the technical difficulties of checking the actual relative humidity by the sulphuric acid method and of maintaining constant relative humidity over long periods. He said that he had not found any moulding below 75 per cent. relative humidity.

Mr. Snow thought that the sulphuric acid method was satisfactory and he had made accurate comparison between results obtained by this and other methods. There was some moulding below 75 per cent. though most of it took place between 100 and 75 per cent. He stressed the importance of taking into account the moisture which comes out of the grain and raises the relative humidity.

Mr. Oxley (Pest Infestation Laboratory, Slough) said that the effects of insects and fungi on stored products were closely linked; insects often infest grain when fungi are present and they also often act as vectors. He thought that special attention should be given to the interaction between insects and fungi.

Dr. Wiltshire said that at the 1946 Conference a recommendation had been made that the problem of fungi in stored products should be discussed at the Commonwealth Mycological Conference and thought that an expression of opinion would be welcome. It is difficult to obtain support for research in this respect.

The Conference agreed that there was urgent need for expansion of research on problems of wastage caused by fungi in foodstuffs and other stored products.

Meeting: Thursday, 22nd July, 2.30 p.m.

Chair: Dr. B. B. Mundkur.

Dr. Mundkur (India), before calling on the first speaker, gave a very brief résumé of important early contributions to the taxonomy of fungi made in India. One Indian fungus had been named by Linnaeus and many by the Rev. M. J. Berkeley, but the greatest contributors were Dr. B. B. Cunningham, Major Barclay, and Sir Edwin Butler. Numerous collections were made by Butler, with whom Dr. Mundkur worked, whilst he was at the Pusa Institute,

and as he sent part to Sydow, who assisted with the naming, there was some difficulty in deciding the types of many of the species described by Butler and named by Sydow.

Paper: 'The organization of Herb. I.M.I.'

Mr. Mason outlined the procedure for dealing with specimens of fungi which was now in operation in Herb. I.M.I. and, by means of a few examples, showed how a well-organized herbarium could be of great assistance to the taxonomist.

Since 1945, when the numbering of the herbarium specimens was started, the unit in Herb. I.M.I. had been each individual collection. The herbarium now consisted of material from some 30,000 collections disposed into some 5,000 species folders. When a collection, either on the host plant or in a culture tube was received into the herbarium, details were entered in an Accession Book before examination and the collection was given an Accession Number.

From the time of its inception herbarium work and laboratory work had proceeded side by side. In the early days specimens were placed in envelopes which were gummed on to sheets and laid away in species folders, slides were kept apart in boxes or cabinets, and dried cultures also were kept separately. When it was found necessary to change the name of a fungus the sheet or packet was redisposed into the required folder, but it was impossible to keep track of slides and cultures. Now slides (in small boxes) and dried cultures are packeted together with specimens in the species folders and all could be redisposed together.

When fresh cultures were sent into the culture collection one subculture was now being dried and put into the herbarium; all subculturing from the one collection bore the same accession number and it should be possible in forty years' time to detect any morphological changes which the fungus might have undergone. Forty years was mentioned for a special reason; the Centraalbureau voor Schimmelcultures had been in existence for just that time.

To demonstrate the value of clerical assistance in the herbarium an example was cited; a collection made by C. G. Hansford, now Herb. I.M.I. 4508, consisted of leaves of a *Sersalisia* on which was material of seven different fungi. Of these, three were parasites on the leaves and the other four were hyperparasites. All received a common accession number and an individual letter, *a*, *b*, *c*, &c. The current disposition of the material into the herbarium was shown in the Accession Book. Each fungus name was then entered in fungus and host books in which the names were arranged alphabetically. With assistance it had been possible to dispose 1,000 collections from Dr. Petrak's Mycotheca generalis into the herbarium in three weeks. Packets not examined are stamped to that effect and are placed under the name on the packet. Assistance in getting material into the herbarium had been given by several students and others released from the forces who were awaiting entrance to the Universities. Since January, 1948, some 600 unnamed new collections and some 10,000 named collections already in the herbarium have been entered in the Accession Book, from which they are being transferred to the fungus and host books.

Taking *Helminthosporium velutinum* as an example, Mr. Mason showed that there had been great confusion in its taxonomy both in mycological literature and in herbaria. Lindau in Rabenhorst's Kryptogamenflora cited five exsiccata published under the name *H. velutinum*. Upon examination of the four represented in Herb. R.B.G., Kew, it was found that they all agreed with one another but disagreed with the description that Dr. Lindau gave. Pursuing the

matter, all British collections referred to *H. velutinum* in Herb. R.B.G., Kew, were next examined. They can be separated into five different species none of which, however, agrees with Lindau's description. Next it was found that Dr. Lindau's description was copied from Saccardo's, which Saccardo himself had drawn up from his examination of Libert Suppl. No. 854. Material of Libert. Suppl. No. 854 was borrowed from Herb. Jard. Bot. de l'État, Brussels, and was found to conform both with Saccardo's description and with type material of *Brachysporium bloxami*. From this it was inferred (1) that literature should always be backed by material preserved in herbaria, and (2) that material preserved in herbaria does not pull its full weight until slides are made from it and kept in the herbarium with it. Great importance is attached to the herbarium worker himself collecting fungi in the field and to the incorporation into the herbarium of slides made from these fresh collections while they are still fresh. The fungus book now shows that 111 separate collections have been disposed in the *H. velutinum* species folders and of these some 50 were incorporated as fresh collections, all represented by material and slides or by a slide alone. The numerous fresh collections are accompanied by slides made from material preserved in other herbaria as follows: from Herb. Persoon in Herb. Lug. Bat.; from folders labelled *Periconia lichenoides, P. ciliare, H. minus, H. velutinum*; and from numerous folders in Herb. R.B.G., Kew, Herb. Bot. Brussels, and Herb. Uppsala.

Paper: 'C.M.I. Culture Collection.'

Mr. Dade said that the Lister Institute's cultures of fungi had been taken over as the nucleus of the now rapidly expanding C.M.I. Culture Collection, and recounted the proceedings of the Specialist Conference on Culture Collections, which recommended that the Commonwealth Mycological Institute should keep and distribute the National Collection of Fungus Cultures (excluding yeasts and human and animal pathogens). About 700 isolations were now maintained at the C.M.I., 400 more were waiting to be incorporated, and new accessions arrived almost daily. During the past year 350 cultures had been issued to research workers, schools and universities, and industrial firms. In the absence at present of any financial allocation, the collection could not expand further and could not fulfil its tasks without additional staff and equipment. A catalogue was in preparation and would be issued in accordance with international agreements on nature and format.

Stock cultures were stored in a refrigerator, and McCartney culture bottles were employed. The latter had many advantages, and their disadvantages of susceptibility to contamination and to mite invasion could be overcome. Organic media were preferred and a number were in regular use. The technique of cold sterilization with propylene oxide had given promising results.

The speaker also described some rapid methods of preparation of microscope slides. Lactophenol mounts could now be sealed with a new melting cement which did not react with the mountant, and which was applied with a special tool. A new mountant which sets hard had also been evolved and was of value for some purposes.

Dr. Wiltshire stated that it was proposed to publish an account of the recording system and technical methods in use at the Institute.

Paper: 'The use of microfilm in systematic mycology.'

Dr. Wiltshire first discussed the use of microfilm in general. As an information centre the Institute is very interested in any means of disseminating information to its clients. This comparatively new technique provides

a means of reproducing printed matter at a cost of about a ½*d.* a page. Compared with reproduction by the expensive photostat machine this is very cheap, for photostat costs at least twelve times this amount and is no cheaper than the reflex method of contact photography, though it gives a much more satisfactory image. One of the disadvantages of microfilm is that the films are 100 feet in length and it takes some time to fill a reel, and for the reproduction of short papers it is better to use the reflex method, or photography through a prism giving a photograph with white text on a black background.

A very great obstacle to the full use of microfilm is copyright. In the United States, where the copyright law is even more stringent than ours, the distribution of single microfilm copies of printed matter for research purposes has been unopposed and it is to be hoped that a similar solution will be found in this country. Another obstacle to its use is the lack of microfilm readers. Plant pathologists must have some means of reading microfilms if they are to use them and that is the reason why an exhibit of three microfilm readers has been arranged for the Conference. For filing microfilms he recommended cutting the films into strips and filing them in 'pochettes' as devised by the French. For ease of reference this system has great advantages over reels, though the labour involved is considerable.

Turning then to the use of microfilm in systematic mycology the speaker said there were two ways in which it might be of service: Firstly, many of the old mycological classics are unobtainable apart from the very occasional second-hand copies. Microfilm presents a way of reproducing any book, to which no copyright attaches, very cheaply. The Institute had now microfilmed 10 such mycological works, including Fries's Systema Mycologicum and Persoon's Synopsis and he hoped before long to put positives from these on sale.

Secondly, microfilm could be of great service in the documentation of new species and varieties of fungi. Since 1940 the Institute had been listing all such species in its *Supplements to the Review of Applied Mycology* and it would be feasible to microfilm the diagnoses of new species with the accompanying figures which are of such great assistance in identification. Each frame of the microfilm would have to be numbered and this number given against the species in the ten-year cumulative index to the *Supplements* now in preparation. Such a scheme would require the active co-operation of all mycologists and the editors of the journals in which the diagnoses occurred. He hoped that all editors present would give their support to such a scheme if it were launched.

Dr. Mundkur asked if copyright applied to all books, and Dr. Wiltshire said that it applies automatically to all publications.

Dr. Findlay (Princes Risborough) said that the Science Library provides photostat copies of articles from United States and Russian journals. Editors of English journals had been approached for permission to reproduce articles and had given favourable replies.

Dr. Hopkins (Southern Rhodesia) asked if copyright applied when copies were issued free.

Dr. Wiltshire said it was the reproduction that counted in copyright, not the sale.

Sir Herbert Howard pointed out that the United States Department of Agriculture had been issuing copies of scientific papers in microfilm for thirty years but had had no legal test case.

Mr. Conners (Canada) thought that if societies were solicited there would be a ready response; he added that the Canadian delegates would be prepared to co-operate.

Dr. Wiltshire then called the attention of the Conference to Mimeographed Publication No. 4 entitled 'A list of common tropical plant diseases'. This list, compiled by Dr. Bisby, gives the names the Institute is adopting for the *Review*. It is prepared on similar lines to the 'List of Common British Plant Diseases' except that synonyms are given with citations. He hoped that Commonwealth plant pathologists would examine the list and send in any comments or criticisms for consideration. It was expected that after revision the list would be printed.

Mr. Robertson (W.A.C.R.I.) asked if it would be possible for the Commonwealth Mycological Institute to issue a broadsheet for the publication of items of interest to pathologists within the Commonwealth.

Mr. Dade said that in the Colonial Empire there was a real need for something of this kind.

A resolution was proposed to cover Mr. Robertson's question.

Meeting: Friday, 23rd July, 10 a.m.

Chair: Dr. G. H. Cunningham.

Discussion: **'The certification of fungicides.'**

Dr. Martin (Harpenden) said that he could only indicate in general terms the objectives, methods, and progress of the scheme which has been adopted by the Ministry of Agriculture and Fisheries and the Department of Agriculture for Scotland for the approval in Great Britain of proprietary fungicides and insecticides. The scheme, which was started in 1942, is confined to branded products used for the control of pests and diseases of growing crops. A further scheme, involving legislation, was set up in 1943 by the Infestation Control Section of the Ministry of Food (now a Division of the Ministry of Agriculture) for the registration of products used for the control of pests of stored foods.

Most countries have experienced the need to give help to the growers with regard to the purchase of proprietary insecticides and fungicides. In some countries products may not be sold or offered for sale unless they have been passed by the appropriate licensing authorities. This method undoubtedly is thorough in its effect since it ensures the non-appearance on the market of worthless preparations; it requires, however, legislation and effective testing and policing organizations. In other cases lists of approved products are issued on the results of official trials, or combinations of the two methods may be used.

In this country the object has not been to control, in any direct way, the sale of proprietaries, but to provide the grower with a list of products he may rely upon when these are used according to the instructions given on their labels, and to enable the advisory officers to recommend groups of products by their proprietary brand names. To achieve these ends a purely voluntary scheme without legislation, official testing, or policing has been adopted. Under the scheme manufacturers may choose whether or not to submit applications for approval, and if an application for a particular product is not submitted or is rejected, there is nothing to prevent the manufacturer from continuing to sell that product. References to approved products are made in the Ministry's advisory bulletins and leaflets on pests and diseases, and growers are recommended to use them wherever possible. A simple leaflet has been prepared to publicize the scheme and it is confidently expected that, following its acceptance by the commercial grower and later by the amateur user, the sale of worthless preparations will effectively be discouraged.

No official testing of products is carried out. Instead reliance is placed mainly upon the provision of standards of chemical composition for the different classes to which the products in those classes have to conform for approval. Before the war, joint committees of the Ministry and the Association of British Insecticide Manufacturers prepared minimum chemical specifications for lime-sulphur washes, tar oil washes, and a limited number of other groups. The specifications were based on the experience, over a number of years, of the research stations and of the manufacturers concerning the minimum standards of composition the products must show if they were to be effective when applied at the normal rates of dilution. Agreed methods of analysis were included. The specifications became official ones and the manufacturers voluntarily undertook to comply with them in compounding their materials. The success obtained led to the adoption by the manufacturers of a guarantee of conformity to an official specification as the main basis for approval under the Scheme.

The preparation of specifications and methods for all the groups of fungicides and insecticides was clearly a long-term project; indeed some are still held up because of lack of sufficient information. In order to expedite matters, particularly in view of war-time necessities, a second basis of approval was therefore included. Under this, products could be approved when it was shown that they had been satisfactory in use and when certain particulars concerning composition and other properties had been declared. The consideration of applications in this category has proved of value, but it is the aim of the scheme to deal with products as far as possible on the basis of conformity to official specifications.

The scheme is operated with the assistance of an honorary Advisory Committee whose function is to deal with applications from manufacturers and to recommend individual products for official approval. The Advisory Committee also forms part of a larger body, the Joint Panel, on which the Association of British Insecticide Manufacturers, the Agricultural Research Council, and the Government Chemist are represented.

Products made to satisfactory chemical standards will not be efficient if they are used at incorrect rates or for purposes for which they are not suitable. Provision was therefore made under the scheme for the approval of the labels for the products. Where the Committee is not satisfied with a particular claim the applicant is required to provide evidence in support of his recommendation, which otherwise has to be omitted from the label before the approval of the product is recommended. The manufacturer gives an undertaking that, following approval, no change will be made in the composition or the label of his product without the agreement of the Advisory Committee. Following the recommendation of approval and the use of an approved label the product is entered in the approved list. On the label the official approved mark signifies the manufacturer's guarantee that the product conforms to a standard approved for the purposes given on the container, and also indicates the inclusion of the product in the approved list. A Certificate of Approval valid for one year is issued, but may be renewed. A fee of three guineas is charged for each annual re-registration; the initial application fees vary from three to five guineas. While no policing is carried out provision is made for the investigation of complaints and the removal, if necessary, of any product from the list. A feature of the scheme so far has been the lack of complaints following the use of approved products.

In the $5\frac{1}{2}$ years during which the scheme has been in operation some 270 products have been recommended for approval and all the important classes of insecticides and fungicides have now been covered. The approved products

have been given in successive editions of a leaflet which has been circulated to advisory officers and to individuals and organizations applying for it; the names of products added to the list between successive editions are notified in the Ministry's Journal.

The scheme has certain advantages. It requires a minimum of staff and avoids the costly official assessment of individual products. The onus of substantiating a particular claim is placed upon the manufacturer, and small firms especially have come to appreciate more fully the importance of themselves carrying out adequate biological tests on their products. The firms find in the scheme a means of obtaining official recognition of their materials and many of them value the checking by independent scientists of the claims and recommendations in their labels. The scheme, which was introduced on an experimental basis, has now become established and has gone a long way towards fulfilling its objectives.

Fuller accounts of the scheme have been published in *J. Min. Agric.*, l, p. 331, 1943; liv, p. 134, 1947; and in the *Ann. Appl. Biol.*, xxxiii, p. 231, 1946.

Mr. Conners (Canada) spoke about registration of fungicides in Canada where these, along with other products used in pest control, must be registered under the Pest Control Products Act, 1939, before they may be offered for sale. The Act was designed to exclude from the market products that were useless or of doubtful value to the farmer-buyer. A vast improvement was thus brought about by the Act; 50 per cent. of the products sold in 1937 disappeared by 1940 due to voluntary withdrawal or the failure of the applicant to secure registration. Up to 1939 publicity was the only means of preventing their use: publicizing the results of experiments was ineffective against glowing testimonials in manufacturers' literature.

An application for registration of a pest-control product must state in detail the chemical and physical nature of the product, the specific and complete claims as to its purpose in pest control, and practical directions for its use. The brand name under which it is proposed to market a product must be given. This name includes the common name and the class of product. Some companies have a distinct brand name that appears regularly in the name of their products, others use a trade-mark. No satisfactory solution has yet been worked out for the same compound under different patented names manufactured by different companies and possibly by different processes, and therefore probably not identical. A brand name must not be misleading. A simple device for designating new products is by means of letters, e.g., Ceresan M. When two products of the same manufacturer are very similar in composition and purpose, the Department of Agriculture may decline to register one of them.

The applicant must disclose the name and percentage of each ingredient, including any inert filler. This information is confidential, but it is useful in assessing possible limitations. The physical form of the product, liquid, paste, or powder, is shown. Where the ingredients may be determined by chemical analysis the guarantee must conform with the limits established under the Act. For a product for which there is no readily available chemical analysis, the guarantee is expressed as 'Satisfactory biological effectiveness for the purposes claimed when used according to directions'. To the application are attached two copies of all claims as to the purpose of the product in which are named the pests that the product will effectively control, and directions for use. Labels also must conform to the regulations. The names of pests, the directions for use, and all claims as to the purpose or effectiveness of the product in pest control are subject to the approval of the Science Service of the Dominion Department of Agriculture.

When registration is sought for a product containing ingredients with which Science Service officers are unfamiliar the applicant is required to supply evidence of its effectiveness in support of his claim. This evidence, to be acceptable, must have been obtained by a reliable agency such as an Agricultural Experiment Station. The onus of proof is upon the applicant, but, in the interests of pest control in Canada, many of the promising products are tested as soon as they are available for field trials. Manufacturers actively engaged in the development of new chemicals for pest control keep in close touch with men testing such materials in Science Service. Registration under these circumstances may be little more than a formality. Applications for registration are still received for new products that are useless or injurious.

The application must show place of manufacture of the product and must be accompanied by the registration fee; if the applicant is a non-resident of Canada, it must be signed by a resident Canadian agent who undertakes to accept responsibility for compliance with the provisions of the Act in respect to the product. A certificate of registration is issued which is valid for one year ending 31 December. A registration number is assigned and the same number retained upon renewal. If the material is classed as a poison this fact is clearly marked and the appropriate antidote is printed on the label. There has been an increasing number of products registered under the Act. In 1941, the total stood at 956, whereas in 1947, 1877 were registered. Fungicides constitute 86 and fungicide-insecticides 62 of this number. A classified index is being prepared.

Enforcement of the Act is accomplished through a corps of 80 inspectors under 8 district supervisors who draw samples from manufacturers' premises, and from wholesalers' and retailers' shelves. Enforcement is secured by the following methods depending somewhat on the seriousness of the offence: (*a*) discussion, (*b*) withdrawal of certificate, (*c*) prosecution, (*d*) detention of the product. The big advantage of controlling the sale of pest-control products under the Act has been the prevention of fraud either through the sale of inferior products or through misrepresentation. Manufacturers and wholesale merchants, often unaware of the inferior nature of some of the products they offer the public, ask for help in securing formulations that would be effective to meet a small but steady demand of their customers.

In reviewing the claims and directions set down for each product advisory officers have an opportunity to present at once the latest information to the public. One of the limitations in reviewing applications for registration is that all the applications covering essentially the same product are not dealt with at the same time. Registration of pest-control products is no substitute for experimental work. If new products are to be used in control of pests, officers interested in certain pests and their control in their respective territories must test the products and publicize the results that they obtain. In the United States experimental work in testing new materials under field conditions is undertaken by the Experiment Stations. Information is brought quickly to the leading grower and contract-grower organizations. The Canadian market is an attractive outlet for the larger companies and permits the Canadian grower to take advantage of U.S. developments virtually simultaneously with the U.S. grower.

At the present time Science Service has no research centre to undertake more fundamental studies on plant protectives. The problem of toxicity of materials used in the control of plant pests awaits investigation. There is also need for a centre where laboratory techniques may be developed whereby series of related compounds may be compared rapidly. These techniques permit basic studies on effective and toxic dosages. They would also be useful

for the evaluation of samples of a product on the market for which there is no chemical means of estimating the percentage of active ingredient present. Studies are also needed on the physiological changes brought about in various plants when treated with a weed-killer.

Dr. Cunningham (New Zealand) dealing with the position in New Zealand said that in 1937 the Plant Diseases Division initiated a biological system for testing sprays and dusts offered for sale by manufacturers to control plant diseases and pests. Preliminary investigations soon showed that chemical analysis was inadequate for the following four main reasons. (*a*) Physical properties of a product, e.g. particle size, are not ascertained, although these often are more significant than the chemical. (*b*) Effects upon plants of therapeutants are very important since, in New Zealand especially, plants are so intolerant that compounds have to be used at considerably greater dilutions than in Australia or the United States. (*c*) Most insects and fungi are selective in their reactions to therapeutants, a feature which cannot be determined by chemical analysis. (*d*) Many organic therapeutants, whether plant extracts or synthetics, cannot be assessed by chemical analysis. Products such as chlorinated phenols and organic mercurials, which are gradually replacing the older types of therapeutants employed, are difficult to analyse, even by specialists, and many cannot be so treated even by manufacturers themselves.

When it was realized that accurate evaluation of a therapeutant was not possible by chemical means, a system of biological testing was initiated. As officers became more experienced modifications in technique and equipment have been introduced, so that to-day it is possible to make evaluations of most products offered for certification with more certainty and a finer degree of measurement than is possible by other means. Modifications are still being added as new types of products become available, or the scope of the work widened. The process is necessarily involved and requires a considerable staff for its operation. The work is under the general direction of the senior plant pathologist, Mr. G. G. Taylor, with a staff of four, assisted by a team composed of the senior entomologist, senior mycologist, and spray chemist attached to the Dominion Laboratory at Wellington. A brief report of general procedure follows. Selected species of plants (usually three) are used both as hosts for selected species of fungi or insects and to assess phytocidal effects of the products under test. Plants are grown singly in pots in insect-proofed glasshouses and when of sufficient size they are inoculated with test fungi or insects. When the disease population is adequate, the therapeutant is applied by means of a special equipment designed by the staff to give to each plant an exact dosage. Numerous replicates are used. At definite intervals assessments are made of the percentage control secured and evaluation made accordingly. As checks standard therapeutants, which experience has shown to be satisfactory for the purpose, are used. Dosages and number of applications for adequate control without plant injury are worked out. Field tests, if required, are carried out in farm or orchard plots in four centres of the Dominion.

Once a product has proved satisfactory it is recorded in 'Certification of Therapeutants' lists published twice a year and distributed widely to orchardists, nurserymen, and farmers. Each product is placed under a general heading, such as organic mercury compounds, particulars given being its trade manufacturer or New Zealand agent, purposes for which it may be used, and dosages at which it should be applied in the Dominion. The first list, issued in July 1937, contained 19 products; the most recent 54.

Certification is voluntary, both on the part of the manufacturer or his agent and the Division. Manufacturers may place on the market non-certified products if they so desire; but experience has shown them that, unless certified,

a product has a limited sale, as to-day nearly 100 per cent. of therapeutants used by orchardists are certified. There are several reasons for this. First the farmer knows that if a product is listed it has been tested under most exacting conditions and is safe to apply. Second, all reputable manufacturers find that it is a good advertising medium to sell only certified products and have strongly supported the development of testing. Third, it offers growers and farmers protection in the event of a faulty batch being sold, which would lead to inadequate disease control or plant injury.

Period checks are made by officers of the Division to ascertain that commercial certified lines are being maintained at the original standard on which certification was based. In no instance has substitution of an inferior product been detected.

A fee of £5 is charged for an initial test, and thereafter 10*s*. yearly. The fee does not cover costs of tests, but does tend to prevent small manufacturers from offering for test products which are of little or no value as therapeutants. Should a product not pass tests, the manufacturer is usually advised as to the manner in which it may be improved.

Work is now being undertaken to develop methods for testing seed disinfectants, preservatives for cordage and fabrics, timber preservatives, and domestic insecticides.

Dr. Findlay (Princes Risborough) asked if the Canadian act also covered fabrics and timber.

Mr. Conners said that it did not.

Professor Brooks (Cambridge) asked what staff was employed in New Zealand for testing protectives.

Dr. Cunningham said that there were four research centres at which about twenty people were engaged mainly in testing therapeutants, but they did other work as well.

Mr. Marsh (Long Ashton) asked what area of orchard was used for testing protectives.

Dr. Cunningham said that initial tests were carried out in glasshouse and laboratory, phytocidal tests were extended to small experimental plots; behaviour of products was tested in field areas.

Mr. W. C. Moore (Harpenden) asked for how many seasons tests were carried on before a product was considered satisfactory.

Dr. Cunningham said that a good idea was obtained by testing for one or two seasons side by side with standard products.

Discussion: 'The use of fungicides in the control of tropical plant diseases.'

Dr. Mundkur (India) dealt with the problem of spraying in India. He reviewed the earlier large-scale operations against *Phytophthora arecae* on areca, *Hemileia vastatrix* on coffee, *Plasmopara viticola* on vine, and *Phytophthora palmivora* on rubber, mostly undertaken in southern India. In the Bombay province, fig-leaf rust [*Cerotelium fici*], cumin blight [*Alternaria burnsii*], and powdery mildews of vine [*Uncinula necator*] and peas [*Erysiphe polygoni*] have been effectively controlled by dusting with sulphur dust. Some years ago, spraying with Bordeaux mixture against potato blight [*P. infestans*] was started in Shillong, Assam, but the work has not been carried out systematically and, at present, it is done only in a few Government farms. Even in the Simla hills, Nainital, and other Himalayan regions where potato blight is a common disease doing much damage, systematic spraying is not practised. In the plains of northern India there are several diseases which could be con-

trolled by spraying, while in the Kumaon and Kulu hills, as well as in Kashmir, where there are extensive fruit orchards, systematic spraying of fruit trees as a routine measure is unknown. In the Central Provinces, where there is extensive orange cultivation, no spraying against some of the common diseases like wither-tip [*Colletotrichum gloeosporioides*], gummosis [*Phytophthora* spp.], or canker [*Xanthomonas citri*] has been done.

Not only is there no precise knowledge of the diseases affecting vegetable and fruit crops in India which can be controlled by spraying but the precise sprays to be used and the times at which they should be applied are not known. There is a necessity, therefore, for research on the more important diseases which affect the vegetable, pulse, and fruit crops and on their epidemiology; spray calendars should be prepared.

The yield of potatoes in the plains of northern India, where their cultivation is concentrated, is very poor mainly on account of the presence of viruses and early blight [*A. solani*]. There is very little that can be done at present to control the viruses, though plans are under way for obtaining virus-resistant varieties. Within the last three or four years efforts have also been made to raise virus-free seed potatoes. This work is still in its infancy, but with the establishment of the Central Potato Research Station, potato certification should receive major attention and certified 'seed' should be available for at least the more important potato-growing areas. In the Plant Protection Schemes, which the provincial governments are putting into operation, one of the principal items is spraying potatoes against early blight.

In India, precise investigations on sprays have not so far been made with the exception of certain experiments carried out in Mysore. The standard formula for Bordeaux mixture is used, but no work has been done to improve upon this and to adapt it to Indian conditions. With proprietary compounds the concentrations prescribed by the manufacturers are used, as no experience has been gained of the concentrations that should be used or the number of times they should be applied under local conditions. Many of these substances, at present, have to be obtained from abroad and there is some dissatisfaction that these cannot be manufactured in India. There has not so far been a large demand for fungicides and industrialists have not taken up their manufacture. As the demand increases it is hoped that these substances will be manufactured in India by Indian firms or by British or American firms using Indian material and Indian labour; this will lower the cost of transport and other charges.

Knowledge in India about spraying machinery is also very scanty. In the planting districts of Mysore, Coorg, and parts of the Madras province and Travancore, certain types of hand-operated sprayers have been in use for a long time and some makes are very popular because they have been found to be very useful after long experience. But the success of a spray depends, among other things, on the pressure at which it is applied. The maximum pressure that can be obtained with a hand-sprayer is never more than 75 to 100 lb. It is only when the pressure is between 200 to 300 lb. that the sprays can be applied in the form of a fine mist whereby both leaf surfaces are finely coated. For this power sprayers are needed. For the present, power sprayers in India will have to be small portable ones that can be transported from place to place and field to field by hand traction, engine power being supplied for generating the required pressure and keeping the pressure constant throughout the spraying period. The Plant Protection Directorate is encouraging the use of 1- to 2-h.p. portable sprayers so that they can be used on the hill slopes or in the flat land in the plains.

One of the difficulties sometimes experienced in carrying on spraying operations against coffee leaf rust or against the leaf fall of orange trees is the supply

of water, which has to be carried long distances, and this becomes the limiting factor in preventing wider use of sprays. This problem may be solved by supplying water-carts on which considerable quantities of water can be transported to the fields.

Spraying, therefore, as a means of fighting disease in India, is generally speaking still in a very preliminary stage. It has not yet become popular even though there are several diseases of vegetables, pulse, and fruit crops which could be effectively controlled thereby. At present an endeavour is being made to popularize the better types of hand-spraying machines and small portable and power sprayers and also such spraying materials as Bordeaux mixture. Along with these operations which will be carried out on a very large scale in many of the provinces in India during the next few years, it is hoped that research on suitable concentration of sprays and the preparation of spray calendars for each crop and its diseases, for the respective provinces of the Indian Union, will also be undertaken.

Dr. Padwick (Imperial Chemical Industries, Ltd.) spoke about the economic difficulties of using fungicides in the tropics and the possibility of reducing them. The economics of using fungicides depend upon the cost of the chemical, the cost of applying it, and the anticipated value of the increased yield of crop. This is an over-simplification of the position, for each of these three components is dependent upon a number of factors which have to be analysed separately for each individual case. Countries like India are mainly farmed by small peasant cultivators whose holdings are only a few acres (the majority under 10 acres). There are, however, large plantations of certain crops, and here and there a few farmers with holdings of several hundred acres, but they constitute only a small proportion of the total acreage under these crops and a still smaller proportion of the total number of growers. It is in this lack of a significant proportion of farmers with moderately large holdings that countries like India, Pakistan, and Ceylon differ from Western Europe and North America. The economic and technical problems of the small cultivator are different from those of a large-scale planter and from those of a middle-class farmer. It is with the economic difficulties of the small cultivator who farms the bulk of India, Pakistan, and Ceylon, in which countries Dr. Padwick's experience has mainly been, that this account deals.

The economic difficulties operating against the use of fungicides by small cultivators in hot countries are: (1) the low level of crop yields and the consequent low value of the crop produced on an acre, hence the cost of spraying may be disproportionate to the increase in yield; (2) the land rental system, which is on a crop-sharing basis, and therefore an increase in crop resulting from improved practices means eventually an increase in rent paid to the landlord, and often less than half of the crop accrues to the cultivator; (3) the poverty of the cultivators who can borrow money for purchase of equipment and chemicals only at a high rate of interest; (4) the small size of holdings, the average size of which in Bengal is 4½ acres, in United Provinces 6 acres, Madras 4½ acres, Punjab 10 acres, and Bombay 12 acres; this renders it uneconomical for a cultivator to invest heavily in machinery; (5) the uncertainty of returns, expenditure on fungicides being regarded as equivalent to a rather high insurance premium against a calamity which quite possibly will not occur; (6) the high cost of equipment and chemicals, most of which have to be imported from abroad, and the cultivator has to meet freight and insurance costs from a western port, unloading charges, customs duty, and inland freight charges; and (7) the unsuitability of present types of machinery, which are designed for middle-sized and large holdings in western countries and are quite unsuitable for the small holdings and small fields of tropical

agriculture often split up and separated by bunds, irrigation channels, and the like.

The poor yields of crops in the tropics, often accompanied by poor prices, constitute the most important single factor. The only way of overcoming this difficulty is through a general improvement in agricultural methods and soil fertility, until the cultivator begins to feel that his crop is really worth protecting. The lesson for the Government attempting to establish the use of fungicides is to start with crops giving high yields and high money value, e.g., sugar-cane and potatoes, for which the cultivator considers expenditure on fungicides and insecticides well worth while. The system of rent paying based on crop sharing makes the cultivator little more than a hired labourer. Governments in India are legislating in an attempt to break down this system and their success will have an important bearing on future agricultural development in that country. The lack of ready cash should not be allowed to prevent the development of the use of fungicides provided they are a sound proposition. Some Governments, e.g., the United Provinces and Bengal, are providing chemicals free to popularize their use. Others argue that it is no use giving the cultivator free chemicals, as the moment the free distribution ceases, the cultivator loses interest and discontinues the use of the chemicals. In any case free distribution can hardly become a permanent feature of the work of the agricultural departments on a scale sufficient to make a substantial difference in the crop out-turn. Eventually the cultivators must pay for the chemicals, and the best way to do this will be through co-operative and agricultural credit societies.

Even under Indian conditions, where labour is alleged to be cheap, the use of power machines can often result in considerable saving of expense. Actual figures on a 1,200-acre rubber estate in South India in 1947 revealed that, apart from the cost of the chemicals themselves, the cost of spraying for control of leaf-fall disease (*Phytophthora meadii*), using a 1½-h.p. machine, was Rs.10 an acre, whereas with hand-operated machines it was Rs.17/4, a difference of Rs.8,700, or £670 over the whole estate in one season. As the volume of water required is decreased due to low coverage, the saving from power machinery is lessened until a stage is reached when it is cheaper to use hand-operated machines. An example of this is in the case of blister blight of tea (*Exobasidium vexans*). where the first five sprayings of pruned tea require only 25 gals. water and the remainder about 40 to 75 gals. per acre. At 25 gals., one man can spray an acre in a day with a hand-operated bucket pump, at a cost of Rs.1, exclusive of the cost of hauling water. As a power machine would require a mechanic to operate it as well as labour to handle the hose, it would cost more than the hand-operated machines, and furthermore there is a heavy capital expenditure for power sprayers. For the bulk of agricultural work power machines are more economical than hand labour, but the capital expenditure is too high for the small cultivator. It is clearly a case for co-operative or Government ownership. Mobile plant protection units, with trained staff, equipped with machines and chemicals, and able to treat large acreages rapidly at a small charge to the cultivator, are the answer to the problem of economics in the small holding. They are also the answer to some of the technical difficulties.

The cultivator has been brought up in a tradition and experience of taking chances, and the hazard of epiphytotics is one of those chances. Better education and propaganda, directed towards informing cultivators of the extensiveness of the losses, is one step that should be taken. Another approach is extensive demonstration on the cultivators' own plots. The experience of many agricultural workers is that although the farmer is pretty shrewd, when

it comes to the economics of a treatment he will adopt a measure for the control of a pest and disease if he sees spectacular results of the killing of the insect or actual protection of the plants against the fungus invasion. In other words, it is necessary to play up to the art of the good cultivator as much as to the economics of the case. Propaganda should, therefore, be directed at least in part to developing in the cultivator a pride in the production of a disease-free and pest-free crop.

The cultivator unfortunately has to pay for freight and other charges. There is, however, no justification for his having also to pay customs duty on chemicals and machinery which are, in fact, the producer goods of a subsidized industry. Every effort should be made to persuade Governments to admit free of duty all fungicides and machines used for applying them. The argument is sometimes met with that certain types of chemicals and machines can be used for purposes other than purely agricultural. This argument is merely a lazy and evasive way of dealing with the problem which has a most harmful effect on agricultural development, and if the customs authorities cannot devise ways and means of deciding whether the products are going to be used for agricultural or non-agricultural purposes, the best way would be to give the importer the benefit of the doubt, allow their admission free of duty, and accept the small loss in revenue in those few cases where they are used for non-agricultural purposes. As many railways in the world are now State-owned, consideration should be given to provision of special low rates of inland freight for fungicides, insecticides, and other chemicals, and also machines used in agriculture.

Another approach to the problem may in some cases be the manufacture of the chemicals within the country itself. The difficulty so far has been that the consumption of fungicides and insecticides in most tropical countries has been on such a small scale that local manufacture was not warranted. The time will no doubt come when some products will be made locally. One encounters a good deal of criticism that fungicides are imported in the form of dilute dusts, e.g., mercurial seed dressings, and that in fact the cultivator is having to pay for diluents which could be produced locally. This criticism, on further investigation, is often unjustified. For example, a mercurial seed dressing to be used as a dust cannot contain more than about 4 per cent. mercury, and with most of the mercurial compounds it is unsafe to use more than about 1 to 1·5 per cent. It would, of course, be quite impossible for the cultivator to purchase the concentrate separately and to dilute it himself with any local dusts. He therefore has to be supplied with the finished product. The only question is whether the diluting can be done within the country. If the volume of trade in the product is sufficient, diluting can be done locally, and in fact most manufacturers nowadays are prepared to consider the local manufacture provided an economic case can be made out for it. So far, however, the cases have been very few indeed. The first step is undoubtedly local mixing or formulation, followed later by manufacture of the active principle within the country.

Most of the machinery at present available for India, Pakistan, and Ceylon is hand-operated and, generally speaking, invented for horticultural use and not for agriculture, where it is necessary to cover big acreages in a small space of time. The example quoted above of the saving in cost of spraying rubber with power machines can certainly be extended to many other crops as well. For example, potatoes require approximately 100 gals. spray per acre and this undoubtedly makes it profitable to use a small power machine. Such a machine must be readily portable, light in weight, of low fuel consumption, and, above all, easy to operate and durable. There are probably machines already in

existence which meet some, if not all, of these requirements, and such machines are being imported into the three countries mentioned. Experience will show where they fail and where they succeed and indicate what improvements are necessary. There is, however, no doubt that power-spraying will become an important factor in reducing the cost of applying fungicides to crops. Governments should be prepared to spend money on research into the development of suitable types of spraying and dusting machinery for use in the fields of the small cultivator by co-operatives of Government departments.

Mr. Owen (W.A.C.R.I.) asked for more details concerning height of trees, rainfall, and method of application of hand-operated sprayers in controlling *Phytophthora* on rubber.

Dr. Padwick said that one type of sprayer used was a double operating hand suction-pump (made in India), operated by 12 men including the water-carrier. Two climbers with spray nozzles on their backs and hoses 200 to 300 feet long were employed. Rainfall was 180 to 250 in. per year. One spray was applied each year, in May, before the monsoon. Trees were up to 120 ft. high.

Dr. Hopkins (Southern Rhodesia) said that in Southern Rhodesia not enough people could be induced to use machines for spraying. Using knapsack sprayers on tobacco twelve men cover 20 to 30 acres a day. One advantage was that they could operate while the rains were on, when heavy machines were easily bogged. Recently 'Pest Control Ltd.' had been concentrating on tobacco. An important factor was the high cost of fungicides owing largely to heavy freight charges, although there was no duty on them. He thought more research should be done on machinery to be adapted to local conditions and on specific fungicides, possibly including products from native plants. He suggested that the Colonial Insecticide Committee now operating might be extended to cover fungicides.

Professor Brooks said that work was being done at Oxford on the bactericidal and fungicidal properties of various plant products.

Dr. Berkeley (Canada) said that the use of D.D.T. with fixed copper dust on potatoes in Ontario had doubled the yield.

Discussion: 'The development of new fungicides.'

Mr. Conners (Canada) opened the discussion. He pointed out that few additions have been made to the organic mercury compounds, important in the control of seed-borne fungi. These compounds are represented by the general formula R—Hg—X, where R is represented by a cyclic or alkyl radical and X may be a basic or an acidic group. Of these ceresan M (ethyl mercury *p*-toluene sulphonanilide) is said to be less irritating to the skin and less volatile than new improved ceresan (ethyl mercury phosphate) and may possibly replace the latter, at present the most popular organic mercury fungicide in Canada for the treatment of cereal and flax seed. It is apparently non-corrosive to metal and can therefore be used in slurry treaters, which virtually eliminate the dust hazard during treatment. To reduce still further the amount of dust escaping during subsequent handling of the grain, spreader-sticker compounds are being added to the slurry. Slurry has also been made with new improved ceresan in mineral oil.

Seed protectants, such as spergon and arasan, are frequently recommended to ensure stronger germination especially when the seed coat has been injured or in anticipation of adverse soil conditions. In Canadian experiments arasan has usually given the better results. The introduction of small amounts of arasan into a strip of soil about the drill row has given considerable protection

against black root of sugar-beet [associated with several fungi]. Damping-off of chilli pepper seedlings is effectively controlled by treating both the soil and the seed with arasan, whereas either treatment alone could not be recommended. Fermate has proved one of the most effective materials in controlling blue mould [*Peronospora tabacina*] of tobacco. Better results were obtained by Ontario growers when a more concentrated solution than that usually recommended (1 lb. per 100 gals. U.S.) was used. Fermate applied as a dust is also effective. Results in the United States indicate that dithane Z 78 and parzate (both are forms of zinc ethylene bisdithiocarbamate) are also effective at slightly lower concentrations.

In the control of apple scab [*Venturia inaequalis*] in 1947 in North America, flotation sulphurs, micronized sulphurs, and lime-sulphur proved just as effective as fermate. Phygon (2,3-dichloro-1,4-naphthoquinone) was superior to all other fungicides, but it caused injury to the trees, while operators often suffered from dermatitis. Puratized agricultural spray (phenyl mercury triethanol ammonium lactate) gave erratic results; it is valuable as an eradicant, but fails to protect foliage from subsequent infections. As it contains mercury it probably cannot be used in cover sprays. Bioquin 1 (copper 8-quinolate) and the glyoxalidines appear promising. In Canada it is agreed that the micronized sulphurs are superior to the wettable sulphurs. Fermate permits more early-season scab on the foliage than do the best sulphurs, but it is effective in the cover sprays. Phygon showed good eradicant and protective value, but at St. Catharines it caused russetting, lack of colour, and staining of the fruit. Venturicide (apparently incorporating phenyl mercury chloride) was extremely caustic and mercurated lead arsenate was ineffective. In the control of pear scab [*Venturia pirina*] in Oregon, fermate and zerlate proved most effective, without injury to the fruit. In the control of apple rust [*Gymnosporangium juniperi-virginianae*] in Virginia, fermate was best, followed by phygon.

Against cherry leaf spot [*Coccomyces hiemalis*], the best control was secured with copper compounds, such as Bordeaux mixture, C.O.C.S. [copper oxychloride sulphate], cupro K, bordow, copper-A compound, and basicop, but in some States they caused injury to the fruit and leaves. Some experiments indicated that fermate and phygon might be used in the early sprays, but a copper material should be substituted after harvest to ensure effective control of leaf spot. None of the newer fungicides is superior to the better-grade sulphurs in the control of brown rot [*Sclerotinia laxa* and *S. fructicola*] of stone fruits. At St. Catharines polyethylene polysulphide increased the effectiveness of the coarser sulphurs as much as extra applications in the schedule. Fermate proved the best material used in the control of black rot [of vine, *Guignardia bidwellii*], but against downy mildew [*Plasmopara viticola*] Bordeaux (5–5–100 and 7½–10–100) was superior to basicop; fermate was ineffective.

In the control of potato blight [*Phytophthora infestans*] there has been a definite return to the use of Bordeaux mixture, particularly at 10–5–100 in the cooler and moister areas where blight is destructive in most years. In trials with the newer fungicides the use of dithane D 14 [disodium ethylene bisdithiocarbamate] has resulted in increased yields. Many workers also report good control of blight outside the areas mentioned. Dithane Z 78 and parzate are nearly as effective and are usually superior to fixed coppers. Chromates also appear promising. The use of D.D.T. in the control of insects has changed greatly the whole problem of protection. In considering the use of any fungicide its effect on the efficiency of the D.D.T. must be considered. It loses its effectiveness when it is added to a material containing lime, and in experiments conducted at the Kentville laboratory it was noted that fixed

copper preparations containing D.D.T. were ineffective in controlling insects. In the control of diseases of tomato, one of the most effective schedules was three applications of zerlate followed by two of tribasic. In Ohio, zerlate, tribasic, and parzate were the preferred fungicides where late blight was not serious, whereas parzate, tribasic, and dithane Z 78 were preferred where late blight was serious. Alternating schedules of zerlate and tribasic or Bordeaux and half-and-half mixtures of zerlate-tribasic and zerlate-parzate were better than most single treatments.

Meuli, Thiegs, and Lyn have studied a number of chlorophenols and their salts as seed fungicides. They found zinc 2, 4, 5-trichlorophenate to be a very effective fungicide. It now constitutes the active ingredient of dow 9 B and has been used in the control of cotton anthracnose (*Colletotrichum gossypii*). Although dow 9 B is effective against *C. gossypii*, this chemical has proved irritating to the operator treating the seed. Arndt has investigated several esters of substituted phenols. Among them the acetate of 2, 4, 5-trichlorophenol was effective in preventing seedling infection by *C. gossypii* at a dosage of 1 gm. per kg. seed. The material is now being manufactured experimentally under the name Seedox.

Thurston, Leach, and Wilson have found that among the numerous compounds of chromium tested as fungicides against potato diseases certain copper zinc chromates have given outstanding results in the control of both early [*Alternaria solani*] and late blight. These chromates have shown insect-repellent properties equivalent to Bordeaux mixture and when used with D.D.T. the yields of treated plots were equal to or surpassed those from fixed copper, dithane, and Bordeaux.

Recent work of Heuber and Nichols on the dithiocarbamates and the control of downy mildew [*Pseudoperonospora cubensis*] of cucumbers and cantaloupes has shown that zerlate, parzate, and dithane Z 78 were as effective as Bordeaux and the fixed coppers in the control of the disease and increased the early and total yields. When the materials were compared as sprays and dusts in 1947 the dusts gave higher yields during hot weather.

Mr. R. W. Marsh (Long Ashton Research Station) spoke about results which had been obtained using new fungicidal sprays for fruit in Great Britain. Much of the developmental work has been done in North America, but preliminary laboratory and greenhouse tests of fungicides, made under strictly controlled conditions, give results which are equally valid on either side of the Atlantic. The fungicidal value of these materials is therefore known. The field performances of the fungicide vary in different countries and American data are not necessarily applicable in Britain, as our conditions, especially in fruit-growing, are radically different from those overseas.

The apple acreage of the United Kingdom is 30 per cent. greater than that of Canada, twice that of Australia or South Africa, and eight times that of New Zealand. In our climate apple scab flourishes and more money is spent in spraying against it than against any other fungus disease in this country. In the United Kingdom, unlike other apple-growing countries, codlin moth is not a major pest in commercial apple plantations and spraying specifically against codlin is unusual. The apple-grower frequently has plantations of plums and black currants as well and it therefore suits him to be able to finish with apple spraying by the end of June. By then new leaf production on apples is well past its peak and the sources of scab infections on the year-old shoots have dried up. Provided that the earlier sprayings have been effective, a spray material with high tenacity and lasting fungicidal value applied in late June has a reasonable chance of protecting the fruit and most of the foliage for the rest of the summer. Hitherto, lime-sulphur has been the fungicide chiefly used

for this purpose and doubtless it will remain in general use here for many years to come. It is cheap, tenacious, highly fungicidal, and also acaricidal. Its disadvantages are that it is bulky, corrosive, unpleasant to use, often damaging, and not compatible with oils. Recently, too, the supply has been inadequate, but possible substitutes for lime-sulphur may be grouped roughly thus: (1) the dithiocarbamates, including the materials known commercially as fermate, zerlate, and dithane, and disulphide which has a wide variety of trade names, such as pomasol, thiosan, tersan, and Jap beetle spray; (2) the organic mercurials of which phenyl mercury chloride has been investigated mainly in England and the material known as puratized N 5 in U.S.A.; (3) the substituted quinones and quinolines such as spergon, phygon, and quinolate; and (4) the glyoxalidine derivatives usually listed under the term 'fungicide 341'. The results of trials made with these materials have recently been published (*J. Pomol. Hort. Sci.* **23**, 185). The black tenacious residue left by fermate makes its use on apples impracticable unless the fruit is washed before sale. Tetramethylthiuram disulphide has been under trial at East Malling for many years and has given somewhat erratic results. These appear to be mild fungicides, comparable to the wettable sulphurs, and needing repeated applications to be of value. Phenyl mercury chloride has an exceptional fungicidal value and in general has not proved phytocidal although certain experimental preparations have caused damage. There is a natural hesitation to adopt this, or other mercurials, until a permitted tolerance has been declared. Preliminary trials with glyoxalidine in the dry season of 1947 gave very promising results, and in the 1948 trials, in spite of wetter weather, glyoxalidine is giving excellent results. Its lack of acaricidal value is a disadvantage that it shares with all the newer fungicides mentioned, but small-scale tests indicate that glyoxaldine may be added to a derris oil spray without adding to the risk of damage. Sulphur-shy varieties are quite undamaged by it. Hydroxyquinoline sulphate showed no fungicidal value in the experiments made in 1947.

The effects of some of the newer fungicides when present as spray residues on processed fruit are important. On black currants, for example, the presence of any of the thiocarbamate sprays may be very undesirable. As little as one part per million of these materials may accelerate corrosion of the can and impair the flavour and appearance of the contents. As processing of fruits becomes widespread the study of this particular aspect of spray residue effects is likely to gain in importance.

Dr. Cunningham said that the testing of fungicides and insecticides could not be dissociated. D.D.T. is harmful to bees and should be used outside the bee season; by destroying predators its application often brings about an increase in the number of red mites. The interaction between fungicides and insecticides has to be checked carefully.

Dr. Berkeley said that apples were not washed in Canada; there were not enough applications to render this necessary; two or three cover sprays, early on, were used.

Dr. Padwick wanted to know how the relative cost of new fungicides compared with the older ones.

Dr. Berkeley said that, generally speaking, there was nothing to touch lime-sulphur for controlling apple scab, but it could not be used in his area, where it caused leaf damage and a reduction in the crop. Fermate is expensive and is not in general use; the first fermate manufactured was more satisfactory than the present product. Flotation pastes and micronized sulphur are good but have to be used more carefully. Organic fungicides are more costly than others and are not being pushed in Canada.

Dr. Cunningham said that cost was a matter of supply and demand—when

first put on the market many fungicides are expensive, when they come into general use the prices come down.

Mr. M. H. Moore (East Malling) said that he agreed with Mr. Marsh, lime-sulphur is likely to be used for a long time for controlling apple scab. Compared with 1 per cent. lime-sulphur (10 points), elemental sulphurs are satisfactory (8 to 9 points); dithane is useless; T.M.T.D. is variable and expensive when used at effective strengths; neither fermate nor zerlate is satisfactory; phenyl-mercuric chloride is quite good, but not always safe, for example, on Cox's at the recommended strength in wet years. There is vast scope for investigation with the new organics and time is an important factor in preliminary tests. Apple rootstocks which are very sensitive to scab are useful for field work. Testing is done first *in vitro*, then on rootstocks, then on small bush-trees, and finally on established trees in plantations. Accurate timing of applications with spraying apparatus suitable for the job is very important.

Joint Meeting with the Commonwealth Entomological Conference

Friday, 23rd July, 2.30 p.m.

Chair: Sir John Fryer.

Discussion: **'Recent developments in pest and disease control machinery.'**

Dr. Kearns (Long Ashton Research Station) made a plea for a more critical attitude among entomologists and mycologists to the application of spray materials. A method of spraying must be not only biologically satisfactory, but also economical. During the past few years rapid advances have been made in our knowledge of insecticides and fungicides, but much has to be done in improving methods and machinery of application. Considerable waste of materials and labour occurs because of inefficient machinery or because a crop is grown in a manner unsuited to get the best out of spraying equipment. The term 'spraying equipment' is used in a wide sense to include all types and not necessarily confined to liquid sprayers. The efforts of the chemists to obtain new materials of a few per cent. greater efficiency are of little avail when application is faulty; the full efficiency of many of the older materials has by no means been obtained.

Up to 1939 much of the British equipment was badly designed and made, ill-matched to the work it was supposed to perform. Apart from a limited amount of power-driven fruit and hop-spraying machinery, it was virtually non-existent for other crops. Even simple machines, such as potato-sprayers, were unreliable. During the Second World War the decision of the Ministry of Agriculture to undertake fruit-spraying by contract on a large scale made it necessary to design tractor-drawn and -driven machines suitable for this type of work. American pumps were imported and installed in English-made chassis. These machines gave an impetus to better spraying and now the demand by growers and farmers for various types of machine of equal efficiency cannot be satisfied. Since the war the demand for pest and disease control equipment of all types for use abroad has been considerable. The demand in many cases cannot be met as the machines have to be designed for special purposes, and development and testing of even a simple machine takes time.

The mycologist is less exacting in his requirements than the entomologist and in most cases he is satisfied with a reasonably uniform deposit (coverage) of a fungicide on the host plant, but the deposit must be maintained as the host plant tissues grow. The entomologist generally demands a complete

coverage of insect and host plant. Each host plant presents its own problem in obtaining an adequate coverage of the pest control material on the stems, leaves, and fruits. The gross as well as the detailed make-up of the crop determines whether complete coverage can be achieved easily or only with difficulty. Thus close rows of dense foliage may render the adequate penetration of droplets impossible even if the droplets are propelled by high hydraulic pressure or air-borne in an air current of considerable velocity. In other cases the nature of the foliage renders wetting difficult, for example *Brassica* foliage is highly repellent to water and the lower surfaces of an apple leaf may be more difficult to wet than the upper. The chemist has helped the problem of spraying by providing materials that lower the contact angle of washes and thereby facilitate wetting. Though efficient wetting is of the greatest importance, it must be remembered that it may be accompanied by reduced retention. Spraying methods used must ensure that a uniform film or adequate pattern of droplets or particles is deposited on the insect or on the 'target area' of the host plant. The material, more particularly fungicides, must withstand leaching by rain and must be non-phytocidal.

The majority of pest control materials are formulated for use with water and therefore a relatively small weight of toxic material is dispersed in a considerable volume of water. This procedure has been one of the main reasons limiting the use of pest control materials in many countries. Alternative methods of avoiding the use of large volumes have been, and are, the subject of much experimental work. Water provides a number of outstanding advantages. It constitutes a safety factor against over-application, as 'run-off' from a surface prevents or greatly reduces the risk of building up a phytocidal quantity of the material, a most important point when dealing with many fungicides and all oil sprays. Large volumes permit the use of a large number of large droplets which contain sufficient kinetic energy to reach the target and it is as well to remember that considerable portions of the target are hit by splash and drip which can only occur with large volumes. Dusts, except in a few special cases when the host plant or target is well adapted to retain them, are not equal in efficiency to washes. The amount of the active material added to an inert diluent and weight applied per acre are adjusted in the case of fungicides to avoid damage to the host plant, though in many cases the lack of adhesion plays the greater part in providing a safety factor. In applying small droplets of concentrated materials it is difficult to avoid over-application, especially of our present-day fungicides and of oils with which the risk of damage to the host plant is considerable; a further difficulty is the propulsion of small droplets to the target, especially where the crop is tall, the foliage dense, and the velocity of the wind high. Small droplets are generally required to remain on the spots they contact, or if individual droplets unite they should not do so to the extent of causing any run-off. The application of aerosols is very much in the experimental stage in this country.

The development in equipment during the past few years has been mostly improvement in detail of design and layout, rather than entirely new principles. It is convenient to divide equipment into two groups, hydraulic and air-flow. The type of hydraulic equipment used varies in different parts of the world according to the cost of labour and nature of the crop. Several interesting hydraulic pumps have been developed in England since the war, ranging from low-pressure centrifugal acid-resistant types operating at 30 lb. per sq. in. to plunger pumps operating up to 650 lb. The low-pressure centrifugal pumps are reasonably well suited for spraying ground crops, using a boom, but for the application of small volumes of small droplet size a much better

performance is obtained at 75 lb. per sq. in. This small increase in pressure greatly facilitates the design of a simple nozzle. High-pressure plunger pumps, operating at 400 to 650 lb. per sq. in., of the compact, totally enclosed, self-lubricated and readily serviced type are now available in this country. Most of them are of the three-throw, short-stroke type operating at about 150 strokes per minute. The pressure controllers on some models like those on some American machines are still inefficient and do not allow of the use of the pump to full advantage. The Ministry of Agriculture has published a broad specification for pump design, and it recommends that four capacities of pump will meet the requirements of fruit-growers; the sizes recommended are 3 to 5, 10, 20, and 35 to 40 gal. per minute delivery at a working pressure of 400 lb. per sq. in. with a maximum of 650 lb. per sq. in. This range of pump sizes satisfies most spraying requirements.

Improvements have been made in the design of nozzles and in their assemblage on 'broom heads' to suit different crops. Much of the work has consisted in tidying up the designs so that the maximum performance can be obtained with the minimum of fatigue for the operator. It would seem probable that the end-point in the design of lance equipment has been reached. The efficiency of lance spraying depends not only on design but very largely on the skill of the sprayman, whose difficulties increase with the height and density of the crop. The greatest waste of wash occurs with large standard trees and the least on bush crops. The toil, expense, and variable personal factor of efficiency associated with lance spraying have turned attention to so-called automatic spraying. This method consists of trailing a spray machine over or past the crop. Adequate coverage of a ground crop is fairly readily obtained by automatic spraying; the main objections are the damage caused to the crop by heavy equipment and the difficulties of hauling considerable quantities of water. The difficulties of automatic spraying of bush and tree crops increases with the height and distance apart of planting. The most efficient coverage is obtained from vertical masts fitted with nozzles of suitable type and spacing. Unfortunately this type of equipment is ill suited to many of our existing plantations, but is adequate for the application of fungicides. It is essential to use a pump of sufficient capacity to suit the land speed of the machine. The full advantages of automatic spraying, namely, speed of application and economy in labour and materials, are only possible if the crop is grown to suit the machine.

Permanent pipe systems, in which the wash is pumped to conveniently placed 'take-off' valves, is a system well suited to permanent crops. The problem of external corrosion of pipes and leakages is now met by fitting the pipes overhead. Frictional losses due to build-up of deposits in the pipes are largely overcome by better layout and arranging return circuits to the pump house.

Unfortunately many of the spraying machines are special units. It is desirable that the basal design is made so that it can be modified without any structural alteration to suit a number of crops. The only modifications should be changes in ancillary equipment.

Air-flow equipment includes (*a*) dusters of many types, (*b*) machines applying the normal type of washes injected at low pressure into large volumes of low-pressure air, and (*c*) machines that apply small volumes of highly concentrated materials into large air volumes of 5 in. W.G. pressure and greater.

Hand dusters which are used throughout the world are still of poor design. The rotary type in which the dust is fed on to the fan blades provides the best performance and better designs are likely to be on the market in the near future. Power dusters using the same principle of operation are gradually

being developed and a tractor trailer machine with an adjustable high clearance axle fitted with a paddle fan delivering about 2,000 cu. ft. of air per minute at 1 to 4 in. W.G. pressure is likely to become a popular type. Open-port delivery of the dust avoids all the complications of multiple spouts and provides equally good results. The use of higher pressures offers little advantage unless it is used with large air volumes. In many instances a dusting machine is a convenient means of discharging a calibrated amount of dust into a wind of low velocity, the wind depositing the dust, or at least a portion of it on the target area.

In the United States and to a limited extend in this country, large spraying machines have been developed for fruit crops. The normal types of wash are injected at about 80 to 100 lb. pressure per sq. in. into a large air stream produced by single stage propeller-type fan; the air carries the droplets into the trees. The air replaces the kinetic energy that would be acquired by the droplets if discharged at high pressure. It seems doubtful if this type of machine can offer any great advantage in performance over a high-pressure pump or pumps using the same horse-power.

Fan equipment is now under development in this country and the United States. Large air volumes are discharged at 5 to 10 in. W.G. pressure and into the air stream small droplets of highly concentrated materials are injected. Preliminary experiments have shown that this technique of application is likely to have many uses once the technical difficulties of building high-speed multi-stage axial-flow fans have been overcome. It is hoped that before long a British-built machine will be available for experimental work in this country. For many years, if not indefinitely, hydraulic pressure equipment will play a big part in pest and disease control.

In conclusion Dr. Kearns expressed the hope that plant pathologists will become more mechanically minded and specify their requirements for equipment more exactly.

Dr. Berkeley (Canada) said that the trend to-day in Canada and the United States, in so far as spray equipment is concerned, is to reduce the weight of machines, to use concentrates, to replace man-operated guns and brooms with mechanical sprayers, and to speed up operations generally. Where successful this cuts down costs, releases labour for other operations, and overcomes the inadequate supply of water existing on many farms.

Several machines are now on the market; these are still in the experimental stage and all models have one or more weak points that must be corrected if they are to come into general use. The new machines can be placed in four categories: (1) the liquid duster which uses dust that is wetted as it comes from the air blast outlet; (2) the mist or fog machines in which concentrated spray solutions or suspensions are atomized by steam, hydraulic pressure, or air blast; (3) the mist sprayer-duster which has a duster attachment so that it can be used as a mist sprayer or mist duster; and (4) the type represented by the speed sprayer which passes dilute or concentrated sprays under low pressure through fixed nozzles, the spray being carried to the trees by air blast.

In the Tifa sprayer (category 2) common fungicides and insecticides are readily dispersed at concentrations having only one-tenth the amount of carrier used in conventional machines. The weakness of this machine is its inability to make good coverage against wind velocities of 10 miles per hour and over. The high temperature used in fogging appears to act detrimentally on some spray materials; another weakness of the fog type of machine is uneven distribution.

Some of the direct air-blast machines can spray an acre from one side in

about 30 minutes. Last year the spray droplets were too large; the particle size should be around 30 to 50 μ. The matter of concentrates is still in the experimental stage, more so than the new types of machine, and no general recommendations are possible as yet. From experimental work mist sprayers appear to be preferable to spray-dusters, concentrated sprays appear to be feasible, and spraying costs are reduced considerably by the use of mist sprayers or other machines using concentrates and projection air blast.

The new speed sprayer is costly and suitable for larger operators only, spraying is purely mechanical, and up to five acres can be covered in one hour using conventional dilute sprays; adapted as a concentrate machine some owners claim to application of 15 acres per hour. In the United States and to a lesser extent in Canada various types of booms are now in use on conventional high pressure machines in an effort to overcome the human factor in spraying and to cut down costs; they consist of a series of nozzles or guns along a vertical or curved mast or tower, thus making spraying a mechanical proposition. There is an interesting development in the prairie provinces in connexion with spray machinery for weed-killing purposes in grain fields. Low-volume spray nozzles used on cheap conventional boom sprayers have given good results.

Another new development in agricultural machinery is the introduction of the slurry method of seed treatment which involves the application of disinfectant in the form of a water suspension or slurry. In operation the slurry is carried in accurate measuring cups on a small conveyor-belt; the cups dump the disinfectant into a measured quantity of seed, and both are mixed by rotating nylon brushes. As much as 300 bushels of maize have been treated in one hour. The slurry treatment increased the moisture content of seeds by not more than 0·5 per cent. Actually the seeds dry so quickly that they can be bagged and stored shortly after treatment, or sown at once.

Sir John Fryer said that two fundamentally different types of spraying equipment had been dealt with, Dr. Kearns had described the efficient but old-fashioned types in use in this country, Dr. Berkeley the revolutionary developments which had taken place in Canada and the United States. He suggested that climatic conditions were in part responsible; there are many days of high wind and rain in Great Britain.

Dr. Kearns said that perhaps people in this country were too cautious. Using low volumes and small droplets (20 to 100 μ) it is difficult to place the spray on the target especially when the wind velocity is usually 4 m.p.h. or more. Small droplets will probably be of value for field crops but not for trees.

Dr. Ross (Canada) drew attention to the directed aerosol or mist sprayer used for fruit-trees; this machine takes one-tenth the amount of water and can be used under exactly the same conditions as the conventional sprayers.

Paper: 'Application of insecticides and fungicides from the air.'

Dr. Gunn (Anti-Locust Research Centre) said that the use of insecticides is not the ideal method of controlling insect pests, but it will have to be continued until appropriate better methods are developed. Aircraft are being widely tested for distributing insecticides. The Anti-Locust Research Centre sponsored three sets of field trials using aircraft against locusts in 1944, 1945, and 1947. Dr. Gunn pointed out that his experience was limited to attacks on locusts.

The problems are how to get a sufficiently homogeneous coverage for the particular insects in question; how to aim that material from the air; the obstacles obstructing the target, or 'shielding'; the assessment of intensity

of deposit of the insecticide; and the factors affecting costs and the consequent promise of useful applications.

Getting an adequate cover of insecticide on the target area depends on how much is used. Modern synthetic insecticides are so powerful that they can be effective at astonishingly low dosages. The difficulty is to get the insecticide spread out properly. It is necessary to keep the dosage as low as possible because of the cost of using aircraft—the lower the dosage the smaller the flying costs. Under the heading of coverage we consider (*a*) granularity or pattern or grain, and (*b*) patchiness. By grain is meant the size and frequency of the droplets or particles of dust in relation to the size of the insect; using one gal. per acre, when droplets are 1 mm. in diameter there will be one droplet per sq. in.; at 0·1 mm., 1·8 per sq. mm.; at 10 μ, $1{\cdot}8 \times 10^3$ per sq. mm.; and at 1 μ, $1{\cdot}8 \times 10^6$ per sq. mm.; patchiness arises because, for example, the insecticide is laid in lines between which there may be imperfectly covered patches.

There are various methods of aiming:

(1) The Porton method. If you simply pour a liquid out of an ordinary aircraft, the liquid is immediately shattered into drops by the rush of air. The sizes of the drops are varied and the size range depends on the speed of the aircraft and the viscosity of the liquid. Under standard conditions you can get a repeatable range of sizes or drop spectrum. Those drops fall at terminal velocities which depend on their sizes; they form a sheet with big drops below and small above, drifting on the wind. If the aircraft flies across the wind while spraying the result is that a wide band of ground is sprayed, the big drops forming the up-wind edge of the band and the smaller drops the down-wind edge. Knowing the drop spectrum of the insecticide, measuring the wind speed, and adjusting the height of the aircraft inversely, the spray can be aimed reasonably well. The Porton method is not readily applicable where drops smaller than 100 μ are required. When it is used, the liquid has to be chosen to give not only the appropriate toxicity but also the appropriate drop spectrum and to evaporate as little as possible while falling to the ground.

(2) The Cloud method. This has a very limited fundamental basis, but is the method most commonly used. Since small drops and dusts cannot be aimed from any height, they have to be released very near the ground. Air which is heavily charged with dust or fine spray is virtually denser than the surrounding air and tends to fall massively; if the material is pushed out under the wings of the aircraft, the wings also tend to push it down. This applies to both fixed-wing aircraft and helicopters. So the fall of a fine spray or dust, which would otherwise be very slow, can be assisted somewhat. Nevertheless, to get it down on to the desired area it has to be applied from tree-top height. The result is that the swathe is usually limited to about 15 yards. In doing this some 5 to 10 times as many runs are necessary as with the Porton method, so the flying time to be paid for is much greater. In addition some sort of mechanism is needed for making fine drops and for spreading the droplets or dust out laterally as far as possible; the weight of such mechanism reduces the payload of the aircraft. This is the usual method of crop spraying or dusting. Much investigation is required to determine the effects of the dispersal mechanism and of the formulation of the insecticide on the coverage obtained by this method.

(3) Curtain spraying is an application of the Porton method of attack to flying swarms of locusts. Neither the Porton nor the cloud method can conceivably give a deposit free from patchiness, even in ideal conditions of wind and machinery. With the Porton method the densest deposition occurs near the

up-wind edge of the swathe. It is then necessary to overlap deposits, which thus produce a fluctuating but always adequate deposit. Other things being equal the farther apart the aircraft runs the greater the peakiness, but the less the flying time to be paid for. Peakiness can be reduced by increasing flying height, but losses by evaporation and by various errors then increase, so a compromise must be reached. In any case the ideal dosage has to be increased to allow for this sort of patchiness and also for losses. The cloud method of aiming has been less scientifically studied. To some extent the descending cloud can be watched and where to lay the next strip estimated. But visual estimation is unreliable as the fine dust or smoke often drifts for hundreds of yards; it looks good, but if it drifts so far it is evidently not depositing much. Perhaps the simplest and commonest practice is to fly along the wind—not across it—and lay the strips as close as appears necessary. There is necessarily considerable waste from drift. Such assessments as I have seen show the deposit in these cases to be very peaky and irregular. Shifts of wind and changes in wind speed produce patchiness in the best-regulated operation. If the ground is heated much, rising currents of air occur which may take fine dust or spray right up. For this reason dusting or spraying by aircraft is best done in the cool of the morning or evening, and may be impossibly wasteful and also dangerous in the heat of the day. Even under the best conditions it is advisable to increase the expenditure of poison to make some allowance for irregularities of wind, flying errors, and the like.

A rain of spray falling on top of leafy vegetation covers the outside leaves first and perhaps may not penetrate to the leaves underneath. For penetrating foliage there seem to be advantages in using a very fine spray or dust. Even then, however, there is necessarily some deposit on the more-exposed surfaces, so there must be a filtration effect, with less material available for the inner surfaces. Some increase in dosage is necessary to compensate for this if a certain minimum cover is required on all surfaces. Investigation is required on the effects of shielding and how to overcome them.

Field tests of the Porton method include the assessment of the density at which the liquid actually reaches the ground over a wide area. Assessments of that kind cannot properly be made by visual inspection and require precise chemical or physical methods. When dealing with a situation which is in any way new, precise assessments are essential. This is particularly true for cloud methods, where there is as yet little foundation of general principles on which to base details of technique, and especially important when shielding is in question.

If the cost of aircraft spraying depended only on the capital cost of the aircraft and cost of petrol and oil, there would be a boom in the method. Commercial operators in the States charge 3 to 6 cents per lb. per acre for the flying only. This is roughly equivalent to between 1*s*. 8*d*. and 3*s*. 4*d*. per acre for a dosage of 1 gal. or 10 lb. To this must be added the cost of the insecticide, which will be considerably greater. To get the charges low the aircraft and the air- and ground-crews must be constantly employed; this means that a large area needs to be dealt with in a short time in one neighbourhood.

It seems unlikely that the Porton method will have a wide application in this country, because the usual target is a crop with insects in it, which requires cloud spraying. Because of the hedges and trees, it seems likely that helicopters may be useful. They are expensive to buy, compared with fixed-wing aircraft, and are expensive to maintain. As there are many crops here which will stand a dusting or spraying of £2 to £4 per acre, their use may still be profitable. They have the advantage over existing types of ground

machine of not damaging the crop by driving through it. Small fixed-wing aircraft are under the disadvantage of requiring airfields, and they seem to be more dangerous to fly at crop height. Where similar conditions obtain in other parts of the world helicopters may become equally valuable. But whenever Porton spraying can be used instead of cloud methods, the heavier fixed-wing aircraft will gain in the load it can carry, the distance it can fly, the speed with which it can cover the area, and the price at which it can operate.

Dr. Kearns is designing a ground machine (airflow) which is intended to take advantage of the best features of both aircraft spraying and ground spraying. A great deal of publicity attaches to aircraft spraying, but comparatively little is known about how it can establish itself in competition with other methods, and much more investigation and field work are needed.

Numerous lantern slides illustrating the methods were shown.

In reply to a question Dr. Gunn added that a 70 per cent. recovery of spray was possible. Even that which appeared to be wasted was not always lost as unexpected reductions in pests were sometimes obtained. It is best to lay a fine spray by 'plane in the early morning. He agreed that ground reconnaissance to locate the target and assess the area and the optimum co-operation by the ground staff were of the utmost importance in reducing costs.

Dr. Davies (Australia) illustrated the danger of drift away from the target area by quoting an example from Louisiana where the complete loss of cotton crops up to 10 miles away resulted after an area had been sprayed with 2,4 D to kill weeds.

Dr. Galley (United Kingdom) described some American practices seen during a recent visit. In Canada the Porton method was used with 4-in. pipes and oils to produce the required drop size. In the United States reliance was placed on low flying using a boom with nozzles. He had seen some damage to cotton in bad weather in the Tennessee Valley. The method of assessment of spray deposit appears to be hopelessly inaccurate. Spraying of 130,000 acres in Dakota using a Gypsy Moth cost about $1 per acre.

Dr. Swarbrick pointed out that helicopter spraying in Holland sponsored by the Government was giving 90 per cent. spray recovery. The deposit was assessed by laying numerous plates at a height of 12 ft.

Dr. Gunn added that plates at different heights in one area gave very different ideas of spray recovery.

Dr. K. B. Lal (India) inquired how smoking and spraying by plane compared as regards effectiveness and costs.

Dr. Gunn replied that it depended on the area to be covered and the drop size used.

At the conclusion of the discussion Dr. Berkeley exhibited a film, kindly lent by Dr. E. J. Rasmussen of the University of New Hampshire, illustrating the new American types of sprayers in operation.

Meeting: Saturday, 24th July, 10 a.m.

Chair: Mr. J. E. Cummins.

Discussion: **'Biological control of insects and weeds.'**

Dr. Davies (Australia) said that he was making a statement, on behalf of Dr. C. J. Magee, about plant pathogens as potential agents in weed control; but that he had been asked to give a short introduction. In Australia, he said, they were accustomed to group weed control methods under four main heads,

ecological control, including any change in the environment such as control of the grazing animal, application of fertilizer, or the use of suitable competing plants; chemical control, i.e., the use of herbicides; mechanical control, i.e., ploughing, cutting, burning; and biological control. Chemical and mechanical control methods were economically practicable in proportion to the value of the crop. Generally speaking, few uncontrollable weeds in Australia were met with in the wheat belt and in the pastoral country, though there were exceptions. Ecological control could and had been applied on pastures in medium-rainfall areas, where the carrying capacity of the land was of the order of one sheep per acre; below this, ecological control was seriously limited by economic as well as adverse environmental conditions. Biological control was generally taken to refer to control of weeds by insects, for it was in this field that spectacular results had been obtained. The low cost of using insects had been a major factor in the popularity of this method amongst Australian graziers. The story of *Cactoblastis* and prickly pear was so well known that an insistent, albeit imperfectly informed, demand existed for a repetition with every known weed.

Dr. Magee's statement indicated that little attention had been devoted to the possibility of using fungi, bacteria, and perhaps even viruses with the appropriate insect vector, as potential agents in weed control. Graziers in Australia frequently raised the question of the possible control of pastoral weeds by diseases. The prospects of such control were not bright and would appear to be dependent on favourable moist weather synchronizing with use; and although a severe infection might then be established maintenance of the epidemic would require prolonged favourable weather. It would be important to establish a high initial infection as fungi and bacteria are not as robust as some insects used in biological control. Regular re-introduction of the pathogen to its field of activity might be necessary. To his knowledge there had been no case in Australia of control of a weed by use of fungi. The possibility was explored during 1925–7 by Mr. H. K. Lewcock of the Commonwealth Prickly Pear Board, who was for a time hopeful that some use might be made of a bacterial soft rot organism which, after introduction to prickly pear, might be spread by the insects also being used (e.g., *Cactoblastis*). The possibility of a fungus or bacterium being used in conjunction with an insect was worthy of consideration in a special case.

As most weeds were exotics examination of the native home of weeds might yield a good pathogen. Dr. W. L. Waterhouse of Sydney University had given consideration a few years ago to introducing a species of *Puccinia*, which was attacking *Xanthium* spp. in Kansas, for trial against Bathurst burr (*X. spinosum*). Use of pathogens of this type would call for great care; there was least risk, however, with organisms of high specificity, such as smuts and rusts. Careful testing and examination of the botanical affiliations of the weed with present and possible future crop plants would need to precede the introduction of a pathogen into Australia.

Dr. Magee drew attention to some noteworthy diseases of weeds which had occurred in New South Wales. In wet seasons *Bassia* spp. were heavily attacked by *Puccinia bassiae* and some plants were killed. This season *X. spinosum* had been affected seriously by a species of *Colletotrichum* which caused a stem and leaf spot, and by a root rot caused by *Rhizoctonia solani*. The severity of attack from *Colletotrichum* in several parts of the State was sufficient to reduce the cost of burr cutting on some properties substantially. A few years ago a crop of wheat appeared doomed to failure by choking with yellow burr weed (*Amsinckia hispida*) until *Sclerotinia sclerotiorum* attacked and killed almost every weed, a good wheat harvest being obtained. He con-

sidered that the question was worthy of some technical attention and proposed making further inquiry into the *Colletotrichum* sp. on Bathurst burr.

Mr. Pugsley (Waite Research Institute) said that in South Australia *Polygonum aviculare* was sometimes severely attacked by a species of *Peronospora*. Wild oat, a bad weed in Australia, was severely attacked in United States by powdery mildew. He thought that people should be cautious in introducing pathogens.

Mr. Wiehe (Mauritius) pointed out that a species of *Striga* parasitic on sugar-cane and maize was attacked and controlled by a *Phytophthora* in Mauritius. He gave two other examples of natural control by fungi, *Euphorbia peplis* by an *Alternaria*, and *Wikstroemia*, an expensive weed to eradicate from pasture, by a *Phytophthora*.

Dr. Cunningham (New Zealand) mentioned the rust on Californian thistle; both host and fungus are perennial, the fungus was easily inoculated into the thistle and often destroyed 98 per cent. of the seed, yet the thistle still spreads at the same rate. Biological control by insects had been tried in New Zealand with no real success. The problem of inoculation was always difficult and conditions had to be favourable. He did not consider that biological control of weeds could be used at present.

Dr. Wiltshire said that the British Commonwealth Scientific Conference in 1946 had suggested that this Conference might consider the question of biological control of weeds by fungi, but he did not think that a resolution was called for unless the opinion of the meeting was that research into the field was sufficiently promising to warrant such work being undertaken at the present time.

Mr. Pugsley considered that inquiries might be instituted and a chance given to study epidemiology.

The Conference decided not to recommend that special work on the problem should be undertaken, but emphasized that they did not wish to discourage any country from undertaking such research if it so desired.

Discussion: 'Forest pathology.'

Dr. Bagchee (India) described in broad outline forest pathology problems in India and explained some of the difficulties encountered in connexion with the protection of hardwood deciduous forest trees from attack by various facultative parasites, sap- and heart-rotting fungi. He discussed the forest management point of view *vis-à-vis* control prescription. He pointed out that the problem is simpler with coniferous tree diseases caused by rusts and root-rotting fungi. Needle and stem rust of *Cedrus deodar* (*Peridermium cedri*), a serious pest in the Himalayas, was dealt with in detail. When checking of nursery stocks for rust was done carefully for two seasons before transplanting no incidence of attack was noticed; the fungus attacks the young trees as soon as they are established in plantations and this is due to close range infection by aecidiospores from the older trees. The biology of the fungus has been worked out, proving the rust to be both autoecious and heteroecious, although the former is most general. The speaker illustrated his remarks by numerous slides.

Professor Malcolm Wilson (Edinburgh University) dealt with forest pathology problems in Great Britain, laying particular stress on diseases of conifers. He said that in this country where plants are raised in forest nurseries damping-off causes little trouble. He pointed out that damaged trees are liable to attack by soil fungi. A variety of the Douglas fir (the coast Douglas)

imported from North America is subject to many diseases. In this country it grows too quickly in the young stages and often suffers from frost damage. It would perhaps be better to grow inland varieties, which are more resistant to diseases such as *Rhabdocline pseudotsugae*. Douglas fir is also attacked by *Adelopus balsamicola* and *Phomopsis pseudotsugae*.

Attention was drawn to the importance of blister rust [*Cronartium ribicola*] in North America where it appears to be spreading southwards. In Great Britain this fungus is killing off *Pinus strobus*, and *P. monticola* has become infected. Currants, the alternate hosts of this rust, were subject to a bad epidemic last year. In some districts there were said to be no pines present; infection can, however, take place for miles around a single infected tree. Some varieties of currants appear to be partially resistant. Notes were given of a few other diseases including *Lophodermium pinastri* on Scots pine and *Keithia thujae* on *Thuja canadensis*.

Mr. Day (Imperial Forestry Institute) said that when the relationship between an organism, as a cause of disease, and its host is investigated, it is necessary ultimately to review the interaction between the two organisms as it takes place in the environment in which they live. Only so can the importance of the parasite as a cause of disease be truly evaluated. It is of particular importance to do this when studying organisms for which some induced condition in the host, usually involving greater or less debility, is necessary for successful parasitism. There are a number of problems, at the present time, in British forestry in which it is of particular importance to ascertain after this manner the primary conditions which make possible the development of the more serious aspects of a particular diseased state. The irregularity in growth and relative failure of some Douglas fir plantations provide one example: edaphic, climatic, fungus, and insect factors are involved, as well as variations inherent in the character of this tree. The dying back of European larch and occurrence of root diseases in large trees, especially with subsequent development of butt-rot, provide others. In all such cases the true evaluation of any one factor as a cause of disease involves a problem in multiple correlation which, at the present time, it is extremely difficult, if not impossible, to solve. Progress may be made, however, by determining what factors are of fundamental importance for the development of the more serious aspects of the disease complex: for example, frost, which acts as the primary killing factor, makes possible the development of larch die-back and canker, associated with *Dasyscypha calycina*, and is similarly responsible for much serious disease in Corsican pine usually associated with *Brunchorstia destruens*. The physico-chemical soil factors, hitherto mostly uninvestigated, which seem to determine very largely the incidence of root infection by fungi such as *Fomes annosus* or some species of *Phytophthora*, provide yet other examples. The solution of problems of this nature in forestry seems ultimately to lie in the adequate fitting of tree species, or of strains within a species, to particular environmental conditions. Thus it is quite plain that in any locality certain provenances of European larch grow much better and are more resistant to disease than are others, while the variations in susceptibility to fungi causing leaf disease of Douglas fir, according to type of strain and climate of situation, are well known.

Dr. Conners said that research had been done in Canada on currant varieties, particularly hybrids with *Ribes manchurica*, resistant to white pine blister rust (*Cronartium ribicola*), with promising results. Some attention has also been paid to white pines in plantations forty years old, where some of the trees were found to be resistant to the rust.

Professor Malcolm Wilson said that Balkan pine (*Pinus puceae*) was

supposed to be resistant and that a few trees in this country growing in a highly infected area for twenty years had not been attacked.

Dr. Bagchee said that pines of the white pine group in India showed resistance to a physiological form of *Cronartium ribicola*; *P. excelsa* is normally resistant; out of 700 cultures, five were pathogenic though not very strongly. The disease does not appear to be spreading in India.

Mr. Samuel drew attention to the other rust on currants, *Puccinia pringsheimiana*, which might be confused with *C. ribicola*.

APPENDIX III

The following report, which was circulated to Governments in mimeographed form only, is printed herewith to preserve continuity of records.

Mr. Ashby's review of the work of the Institute, 1935–9

ANXIETY in regard to revenue was the keynote of the Director's review of the work of the Institute for the preceding five years, presented at the Conference of 1934. Owing to economic depression certain Empire countries had temporarily stopped annual contributions. A Committee of the Conference examined the Institute's financial requirements and expressed the opinion that the minimum annual expenditure necessary to continue it on a satisfactory basis during the following five years was £7,700. Contributions in 1933–4 had amounted to £6,010. Fortunately the depression passed and the contributions were restored during 1935 6. They were, however, still insufficient to meet the need for increase of staff on the scientific and clerical sides which, being deferred, had become urgent. Relief came through the Commonwealth Scientific Conference of 1936. A request for an increase of income of some £600 from the Dominions and United Kingdom was found acceptable to the delegates, duly reported to the respective Governments, and materialized in 1937–8. The Conference also recommended an increase in the subscription rate of our monthly *Review of Applied Mycology*, which had been 21*s.* for a number of years. *The Review of Applied Entomology*, Series A, had been raised to 30*s.* in 1935. An increase to that amount became effective in January, 1938, after giving ample notice to subscribers. Empire subscribers receive a rebate of 20 per cent. if they pay us direct. Subscriptions have kept up in spite of the rise, and new ones have come. A small reduction in distribution has been due mainly to self-imposed restriction of the free list by contributing Governments. For many years there had been a loss of about £200 on the *Review*. For the financial year ending 31st March, 1939, the cost of printing and distributing the *Review* was exceeded substantially by receipts from sales, which went to well over £1,000. In 1938–9 contributions amounted to £8,100, total income was £9,100, and estimated expenditure £8,700.

Owing to the resignation of the first Director in 1935, some readjustments of staff became necessary. Dr. Wiltshire, the Assistant Director, took over the editing of the *Review* and Mr. Dade, who had been Mycologist in the Gold Coast for many years, joined as Assistant Mycologist and Sub-Editor. Mr. Mason, the former Assistant Mycologist, became Mycologist. In January, 1937, Dr. G. R. Bisby came from the University of Manitoba and joined the staff as Assistant Mycologist. The Institute was fortunate in obtaining the services of that experienced plant pathologist and systematist. On account of the present Director's retirement at the age limit at the end of this year, Dr. G. C. Ainsworth, well known in this country for his work on virus diseases, joined the scientific staff in June of the present year to assist dominantly with the *Review*. It is hoped that he may find the new work congenial.

During the period under review List II, fascicle 3, General Part of the 'Annotated Account of Fungi received at the Institute', by Mr. Mason, was issued in 1937, and 'Mycologists resident in the British Empire, 1938' in January, 1938.

By request of the Secretary of State on behalf of the local Government, Mr. Dade went to the Gold Coast in May, 1937, to investigate a presumed new disease of cacao. His comprehensive report was published as a Council Paper

by the Government of the Gold Coast in December, under the title 'Swollen Shoot of Cacao. Report on Mr. H. A. Dade's Visit to the Gold Coast.' He found the dominant trouble in the restricted area affected to be a dieback resulting from inadequate shade and shelter accentuated by drought; a peculiar swelling of the shoots was regarded as of secondary importance; the cause of the condition, not yet clarified, was apparently non-parasitic.

The work of the Institute has been continued along the already familiar lines of investigation, identification, and the collection and dissemination of information. Investigation, which is undertaken by all the members of the scientific staff, has been concerned mainly with the study of critical genera and species of fungi received for identification, and more or less of phytopathological importance.

Dr. Wiltshire has continued his critical studies of *Alternaria* and related genera, and his fundamental paper on the original and modern conceptions of *Stemphylium* was published last year. His time, however, has been mostly given to the editorial work on the *Review*.

Mr. Mason, although giving most of his time to identifications, was able to write up the general part of the third fascicle of the second annotated list of fungi received, which was issued in 1937. In it he has attempted to establish a more correct method of classifying and naming the imperfect fungi which is better suited to the needs of applied mycology. The distinction made between 'dry' and 'slime' spores has been very helpful and it is evident that the fascicle has been widely studied and appreciated by plant pathologists and other applied mycologists. The special part of the fascicle is about to go to press, and promises to be as interesting as the general part.

Mr. Dade, much of whose time has been given to the *Review*, has interested himself in a critical study of the genus *Aspergillus* and has identified many species received. He continued his studies on heterothallism in *Ceratostomella paradoxa* and published a paper on 'New Gold Coast Fungi' in 1937. His visit to the Gold Coast in 1937 has been mentioned already.

Dr. Bisby, since joining in January, 1937, has met heavy calls for identification, including many soil fungi. Although specially interested in the rusts, he has completed and published this year a critical taxonomic study of the genus *Trichoderma* which had aroused his interest in connexion with earlier studies on soil fungi in Canada. *Trichoderma* has received much attention from plant pathologists in recent years on account of its antagonism to some soil-inhabiting pathogenic fungi. A study which goes far towards clarifying its taxonomy should be widely welcome. Dr. Bisby has had the satisfaction of seeing the publication in book form, in February of the present year, of the 'Fungi of Manitoba and Saskatchewan', a very comprehensive annotated list of the fungi in the two provinces, of which he was the joint but main author.

During the period under review I have been called on to identify many species of the important phytopathogenic genera *Phytophthora* and *Pythium* of Empire and foreign origin. Data have accumulated which it is hoped may be put on record shortly.

Mention has been made of the fact that, in spite of an appreciable increase in the subscription rate of the *Review*, there has been only a slight fall in distribution. Two-thirds of the distribution is to subscribers, with the major proportion in foreign countries. This speaks well for the range and quality of the abstracts. The literature of plant pathology tends more and more to an increase in technicality imposing greater demands on knowledge and care in the editing of an abstracting journal. The continued high standing of the *Review* with plant pathologists in all countries must be recognized as due to the care and devotion of Dr. Wiltshire and Mr. Dade and the steady work of

the abstractors. The spontaneous appreciation of outstanding workers has been a heartening reward.

The identifications made at the Institute have enabled mycologists, especially in the Colonies and Dependencies, to publish preliminary or revised lists of the diseases of their economic plants, or lists of fungi with host indexes. During the last five years preliminary, supplementary, or revised lists of fungi and diseases have been made available in print for most Empire countries in Africa, for several in the West Indies, and for Ceylon and Cyprus.

Mention should be made also of the publication in 1935 of the 'Fungi of Bombay' with a host index, and of the issue in 1938 of *Supplement 1* of the 'Fungi of India', increasing the number of fungi recorded in India by over 500 species.

The Conference of 1929 adopted a resolution suggesting that the Institute should assist in the publication of books on diseases of tropical crop-plants. Financial aid was not feasible. Reference may be made therefore to the publication in 1934 of 'The Diseases and Curing of Cacao' by the late H. R. Briton-Jones, 'Diseases of the Banana' by C. W. Wardlaw in 1935, and 'Diseases and Pests of the Rubber Tree' by the late Arnold Sharples in 1936. Assistance was given to the authors with the bibliographies and identifications of fungi.

Reference may be made to some resolutions adopted by the last Conference. The form of a general health certificate to accompany plant imports was recommended for adoption by Empire countries. This form was printed in the report of the Conference. It has been adopted widely by Empire countries. A marked improvement in the quality and freedom from disease of imported plant material should result, especially into the Colonies and Dependencies where an established plant-import inspection service did not exist.

A second resolution recommended that measures be taken to enable Empire countries to maintain up-to-date information regarding legislation dealing with the import of plants. This recommendation has been met for the Colonies and Dependencies by the Colonial Office publication, issued in 1937, 'A Summary of Legislation relating to the Introduction of Plants into the Colonial Dependencies of the British Empire as at the End of December 1936'. One trusts that this useful summary, brought up to date, may be reissued at suitable intervals. In consequence of the action taken by the Secretary of State in response to this resolution, the Institute has received from many of the Colonies copies of new Orders issued under the Plant Protection Ordinances; these are noticed in our *Review*.

A third resolution drew attention to the risks of introducing plant disease by air transport. Empire countries are now fully alive to these risks owing to the recent great development of air transport, and appropriate legislation is or should be now in force controlling plant imports by air-mail and in passengers' baggage.

A fourth resolution drew attention to the need for continued and intensified research, especially in the United Kingdom, the Dominions, and India, into methods aiming at the biological standardization of fungicides and insecticides. Some of the research stations in the United Kingdom are engaged in this work. As evidence of that reference may be made to the publication in 1936 of a second edition of Hubert Martin's 'Scientific Principles of Plant Protection', and also in 1935 of the less widely known but very useful 'Plant Protection By the Aid of Therapeutants' by G. H. Cunningham, head of the Plant Diseases Division of the Plant Research Bureau in New Zealand. In recognition of the need expressed in the resolution a session of the present Conference is being devoted to the subject in regard to fungicides.

Turning to the Institute quarters, the original plan was for a larger building. The result of adopting a smaller plan has become evident after nine years of occupation. There is urgent need for extension to provide for the ever-growing library, the herbarium, collections of reprints and pamphlets and stocks of the *Review*, and, owing to the increase of staff, laboratories for the use of visiting mycologists from overseas. The Conference may think fit to appoint a committee to examine our requirements in regard to such an extension and to make recommendations. Alternative plans are available, and rough estimates of the cost.

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